FEBRUARY 25, 1957

AVIATION WEEK

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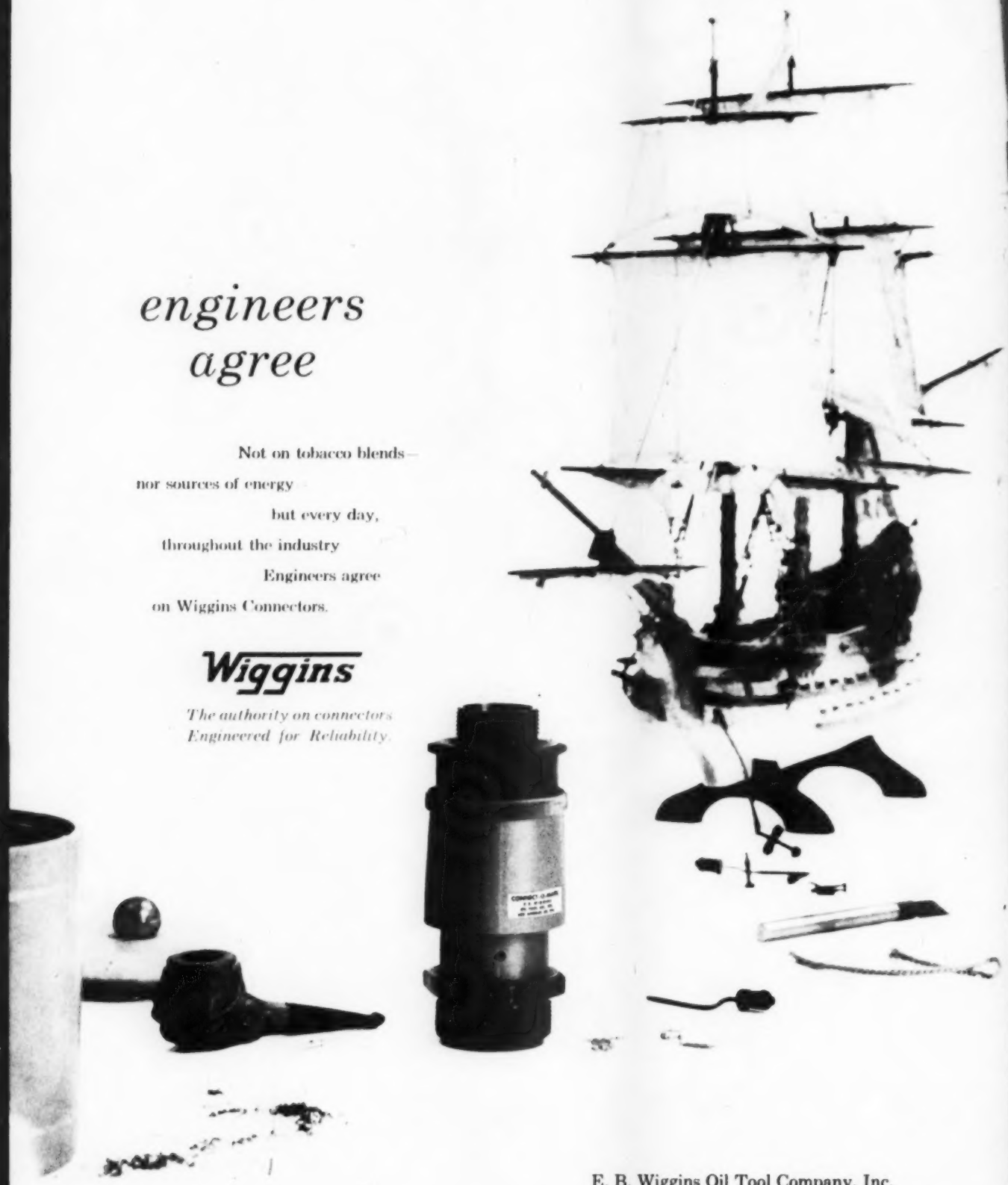
Engineered for Reliability



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Pumps and HYTROL
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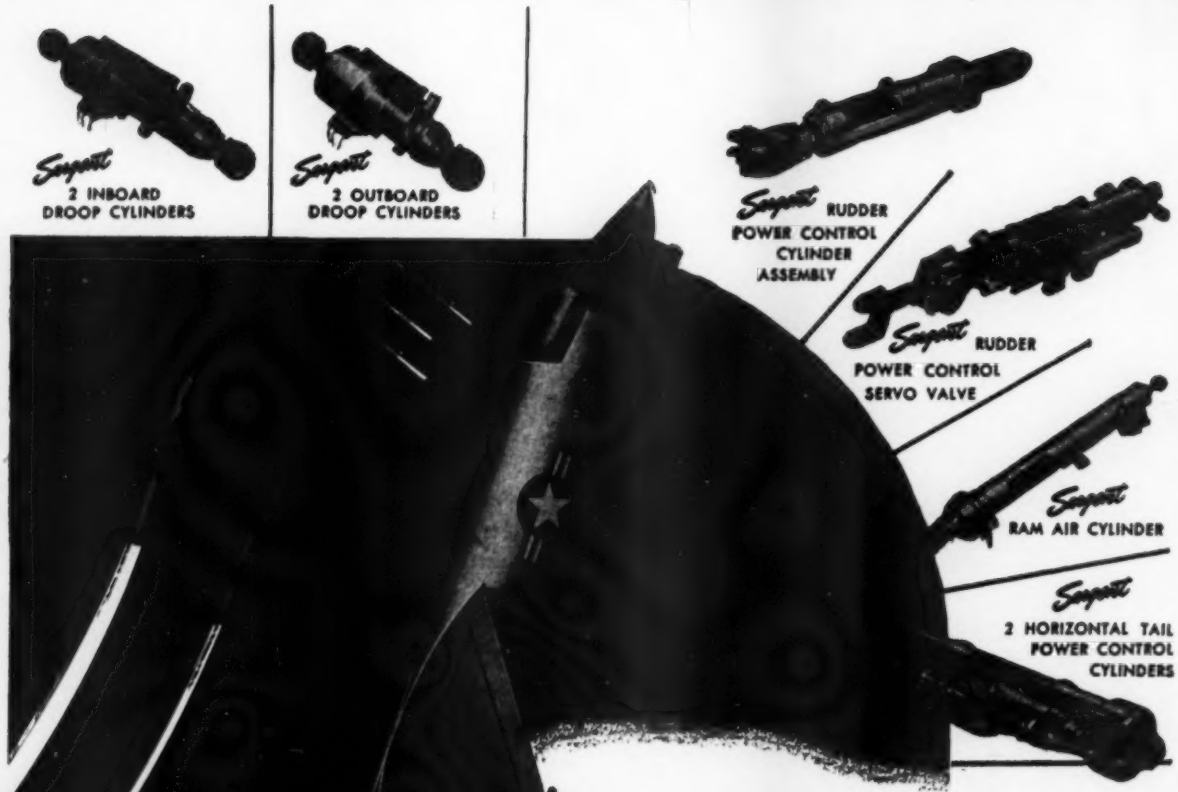
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Nine Sargent quality units have been selected to provide Chance Vought's F8U-1 Crusader with instantaneous, positive, feathertouch response.

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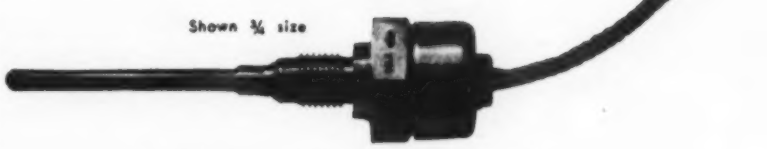

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- AVAILABLE IN VARIOUS RANGES FROM —300°F. TO 1500°F.
- RESISTANCE CHANGE OF 100 OHMS OVER SPECIFIED RANGE

Trans-Sonics Type 1300 Bulb Temperature Pickups are precision high-speed resistance thermometers with a platinum resistance winding as the sensing element. Each Type 1300 Bulb Temperature Pickup is individually calibrated and supplied with its own calibration sheet. The temperature interval over which the 100 ohm resistance change will occur may be as low as 100°F. These Pickups are designed to withstand pressures up to 3,000 psia. When specified they can be furnished for installations in *corrosive* liquids or gases. Their leads can be exposed to temperatures up to 600°F. and may be detached from the instrument proper for shortening or easy replacement. Write for Bulletin 1370 to Trans-Sonics, Inc., Dept. 7.

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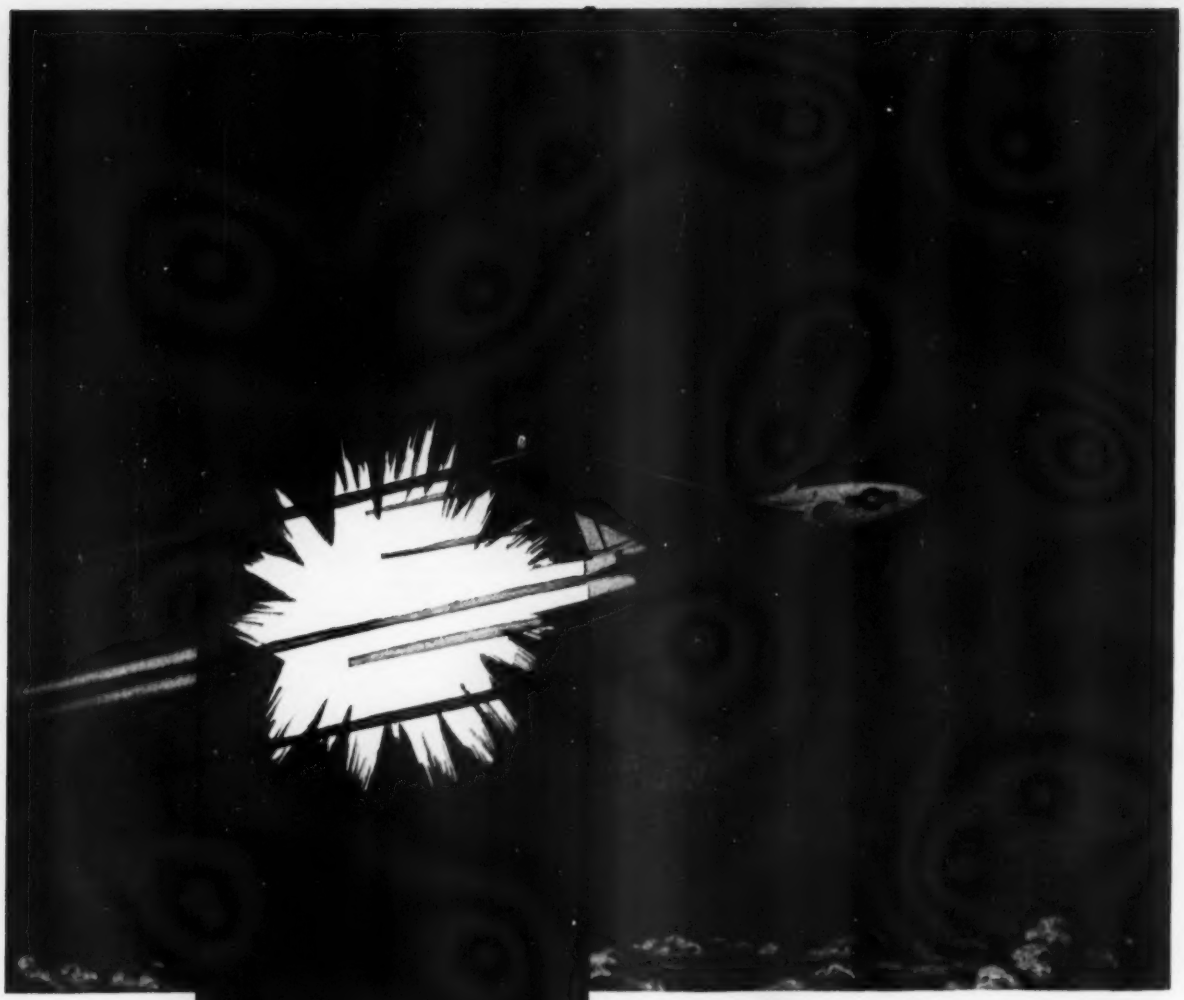
SPECIFICATIONS

CASE CONSTRUCTION: Stainless Steel
ACCURACY: ±1% of full scale range
PRECISION: ±0.2% of full scale range
MAXIMUM CONTINUOUS CURRENT: 20 ma rms (averaged over 1 second)
TIME CONSTANT: Less than 2.5 seconds in agitated water
ENVIRONMENTAL OPERATION CONDITIONS
PRESSURE: 3000 psia (at room temperature)
VIBRATION: 1" double amplitude, 0 to 22 cps ±25g, 22 to 2000 cps
SHOCK: 60 g in any direction, per para. 4.15.1 of MIL-E-5272A (10 milliseconds shock)

For Transducers, See Trans-Sonics

Trans-Sonics, Inc.

P. O. BOX 328 LEXINGTON 73, MASSACHUSETTS



BREAKING THROUGH THE HEAT BARRIER

The faster they go, the *hotter* it gets inside guided missiles and jet aircraft. The heat comes from friction of air and from electronic equipment.

Heat from friction cannot be eliminated, but heat from electronic equipment can be greatly reduced by using transistors. However, existing transistors could not be used because they would not operate at high enough temperatures. Now, Raytheon's new PNP silicon transistors function reliably at high temperatures in jet and missile equipment—give 90% savings in size, weight and power.

By helping to solve this difficult problem, silicon transistors by Raytheon are making a significant contribution to the efficient operation of the latest airborne military equipment.

There are more Raytheon transistors in use than any other make.

Excellence in Electronics

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an important OPEN LETTER concerning Your Aircraft Stainless Requirements

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Here are some of the advantages we offer you:

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2. There is no difference between warehouse and mill stainless pricing. When you place your order with U. S. Steel Supply, no matter if it is shipped from warehouse stock or mill production, the price is the same.

3. Our inventory is ordered to our own specifications which are tailored to meet the requirements of many of the aircraft specifications. In all cases the orders accepted for stainless steel can be certified to the applicable aircraft specifications at no extra charge.

4. In addition, our Newark, Los Angeles, St. Louis and Dallas warehouses maintain large inventories of Type 301 sheets, annealed ¼, ½, ¾ and full hard produced to MILS 5059A; Type 321 and 347 sheets produced to MILS 6721; Type 321 rounds and hexagons produced to QQ-S-00763A.

5. If you require assistance, our stainless representative or metallurgist is ready to draw upon his wealth of experience to help you. If he does not know the answer, he knows where to get it for you.

Many of the nation's leading aircraft manufacturers and aircraft component parts manufacturers are regularly using our services. If you are not one of them, please call us. We will welcome an opportunity to be of service to you.

NEW BOOKLET AVAILABLE ON AIRCRAFT STEELS OF TOMORROW

Have you been wondering what is being done in the development of aircraft steels to meet the challenge of supersonic flight? A recently published United States Steel pamphlet, "Special Steels for the Aircraft of Tomorrow," will bring you up-to-date on what U. S. Steel has been doing in its research and development program for your industry.

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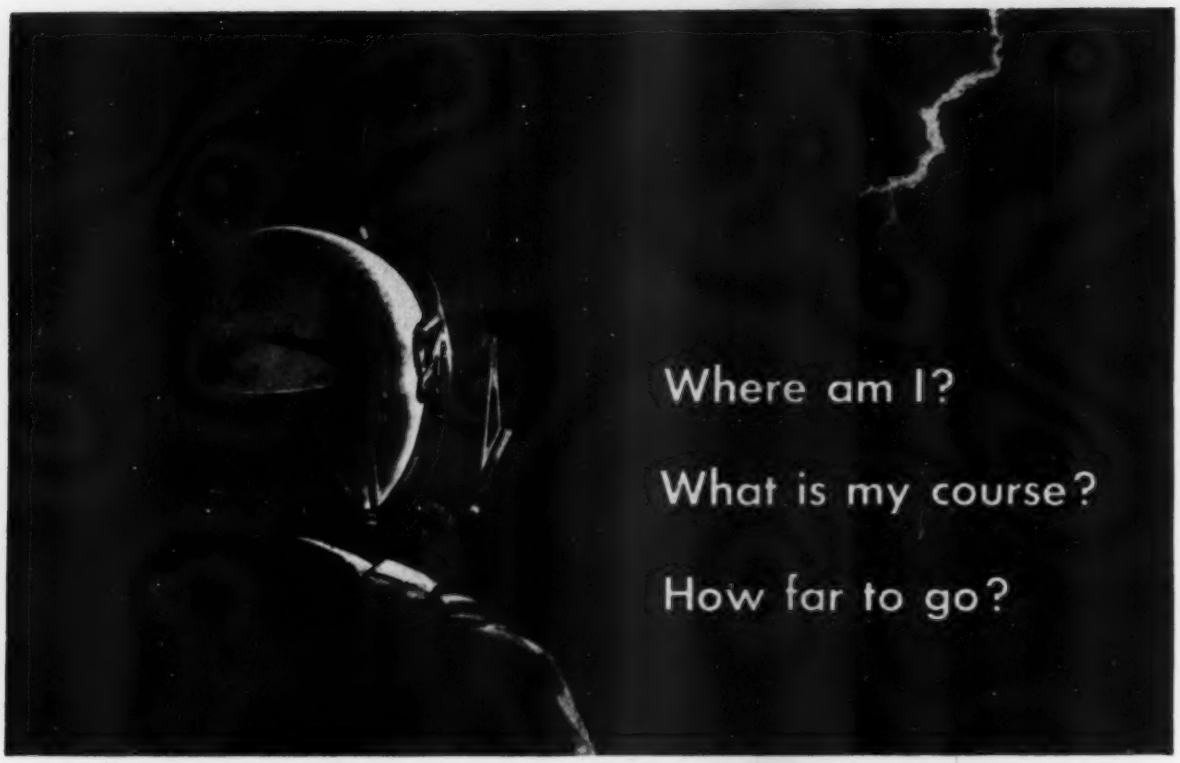

NEW *PROVEN* COURSE AND DISTANCE COMPUTING SYSTEM SOLVES YOUR NAVIGATION PROBLEM—*FICo's ASN-7*

The flight-tested ASN-7 answers every navigational question the pilot can ask. Self-contained, automatic, this dead reckoning system is revolutionizing aerial navigation. In operation, the pilot sets in the latitude and longitude of his take-off point and of his destination, and the system guides him in—regardless of how his course changes, regardless of distance, and without air-ground or ground-air communication. Alternate destinations can be inserted and stored.

This FICo system can be installed in any aircraft—from jet fighters to tankers, bombers, transports and airliners. And it is in production now! It is smaller in size and lighter in weight than any comparable navigation system now in existence, and offers *extreme* accuracy. The ASN-7 features automatic variation and can be supplied with polar capabilities, automatic fix correction, and automatic drift and ground speed. For additional information, write to Airborne Equipment Department, Ford Instrument Co., on your letterhead.

FLIGHT INDICATOR of this system displays ground track, required course, heading error, and distance to the destination.

COMPUTER CONTROL feeds wind, variation, and destination data into the system. It displays present position, wind speed and direction, variation, and destination coordinates.

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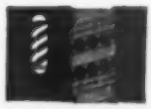
SAGINAW b/b SCREWS are guaranteed 90% EFFICIENT!

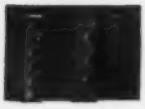
Require 4/5 LESS torque than Acme Screws for same linear output on Actuator and Positioner Applications! Saves space, weight!

WHAT IT IS AND HOW IT WORKS

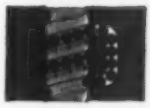
Let's start at the beginning, with the familiar principle that there's far less friction in *rolling* than in *sliding*. By applying this principle,



Like stripes on a barber pole, the balls travel toward end of nut through spiral "tunnel" formed by concave threads in both screw and mating nut.



the *Saginaw ball bearing Screw* radically increases the efficiency of rotary-to-linear motion (and vice versa). Instead of *sliding*, mating surfaces *glide* on rolling steel balls.



At end of trip, one or more tubular guides lead balls diagonally back across outside of nut to starting point, forming closed circuit through which balls recirculate.

SIX DESIGN ADVANTAGES

1. Vital Power Savings. Permit much smaller motors with far less drain on electrical system, simpler circuitry.

2. Space/Weight Savings. Screws themselves are smaller, lighter; permit smaller motors and gear boxes; eliminate auxiliary equipment required by hydraulics.

3. Precise Positioning. Machine-ground type will position components far more precisely than hydraulics or pneumatics; tolerances on position are held within .0006 in./ft. of travel.

4. Temperature Tolerance. Normal operating range from —75° to +275° F.; in selected materials, will function efficiently as high as +900° F.

5. Lubrication Latitude. If lube fails, will still function with remarkable efficiency. Units have been built and qualified for operation without lubrication.

6. Fail-Safe Performance. Far less vulnerable than hydraulics; Gothic-arch grooves, yoke deflectors and multiple circuits provide added assurance against failure.

SAGINAW b/b SPLINE

Utilizing the same basic *gliding ball* principle, Saginaw has developed the *Saginaw b/b Spline* which radically increases the efficiency of transmitting or restraining high torque loads.

Averages 40 times lower friction coefficient than sliding splines!

It can be fitted with integral gears, clutch dogs, bearing and sprocket seats, etc., for use with a wide variety of electrical units. Units have been built from 3 inches to 10 feet long—3/8 to 6 inches in diameter.

Available in custom machine-ground and stock rolled-thread types. Units have been built from 1½ inches to 39½ feet long—⅜ to 10 inches in diameter.

Saginaw ball bearing Screws & Splines

SAGINAW STEERING GEAR DIV., GENERAL MOTORS CORP., SAGINAW, MICH.

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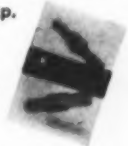

Saginaw Steering Gear Division, General Motors Corp.
b/b Screw and Spline Operation
Dept. 6B, Saginaw, Michigan

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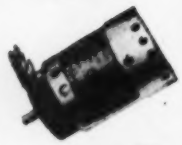

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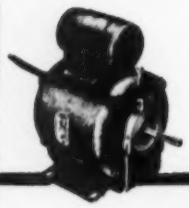
50, 60, 400 cycles and variable frequency; single and dual frequency; single, two and three-phase operation; 1/3500 to ½ hp; 1" to 6⅝" diameter.

Precision Gear Motors



50, 60, 400 cycles and variable frequency; single and dual frequency; single, two and three-phase operation; high torque; wide variety of gear ratios up to four speeds.

The development of small, special purpose rotating electrical equipment had its origin at Eastern Air Devices, where since 1942 know-how and experience in the design and production of miniaturized equipment has been meeting specialized requirements.

If your need is small motors, blowers, fans, actuators or generators EAD is ready with production capacity to handle your volume requirements, and with engineering design services to develop and produce a unit to meet the most exacting specialized need.

Write for complete information on EAD's standard line and specialized design services yours for the asking.

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Alternators available from 1" diameter, .01 va; to 6⅝" diameter 800 va; power up to 400 volt-amps; wide frequency range. Low harmonic content—units are capable of delivering a sine wave with less than 2% distortion. Dual frequency units produce a combination of frequencies and voltages for special applications.

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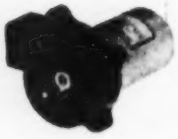
Axial Flow & Vane Axial



A complete line of lightweight, centrifugal blowers, ring mounted fans and vane axial fans for cooling electronic equipment or for general purpose use.

Capacities range up to 1000 cfm with special designs available for high static pressures. Single and double ended—50, 60, 400 cycle and variable frequency (360-1600 cycles).

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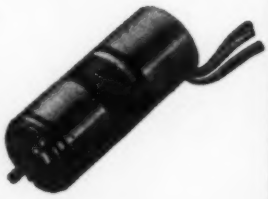

Eastern Air Devices, INC. 397 Central Avenue Dover, New Hampshire

"QUALITY STANDARD OF THE INDUSTRY"

How to use a Wave Analyzer on an Ocean Wave

(or any low frequencies from 1/10th to 5 cycles per second)

A head-on attack on this problem will soon uncover the disconcerting fact that wave analyzers just don't come this big. Those of a more comfortable size generally operate on frequencies of five cycles per second and more.

But frequencies as low as 1/10th cycle per second – like earthquake waves, ship motion, and low-frequency vibrations of large machines and structures can be fed to conventional wave analyzers with completely satisfactory results. Magnetic tape recording provides an essential conversion step between.

Bell Aircraft Corporation's magnetic-recorder installation aboard the SS Mariposa for study of ship motion.

Speed change on the Ampex FR-100 is accomplished quickly and easily by a selector knob and switch.

Two Ampex FR-100 magnetic recorders were purchased and installed aboard the SS Mariposa for Bell Aircraft Corporation's study of ship motion at sea. The frequencies encountered were far below one cycle per second. These were recorded at the lowest tape speed on the recorder (1⅞ in/sec.). Reproducing the tape at the highest tape speed (60 in/sec.) multiplied the frequencies by 32. Recopying onto the second recorder and speeding up again increased the total speedup to 32 x 32 or a total of 1024. As an example, a frequency of 1/10th cycle per second became approximately 100 cycles per second and was easily separated and measured by wave-analysis equipment.

The Ampex FR-100 recorder has six standard speeds from 1⅞ to 60 in/sec. in the ratio of 1, 2, 4, 8, 16 and 32. Recopying accomplishes further multiplication by powers of two. Even a second recopying is perfectly feasible just in case you are interested in a frequency multiplication of 32,768.

Putting low frequencies onto magnetic tape requires an FM-carrier recording. On the Ampex FR-100 this is conveniently provided by plug-in amplifiers. Frequency response at 1⅞ in/sec. tape speed is 0 to 312 cycles/sec. At 60 in/sec. it is 0 to 20,000 cycles/sec. Besides its ability to record very low frequencies, FM carrier recording has the very desirable attribute of high instantaneous amplitude accuracy. Thus, the reproduced waves retain their original form very accurately through any amount of speedup.

If you have a problem that might be solved by data speedup, we would be pleased to furnish further information. Others of magnetic tape's remarkable capabilities will be the subjects of a continuing series of these bulletins. Would you like copies mailed direct? Write Dept. UU-3134

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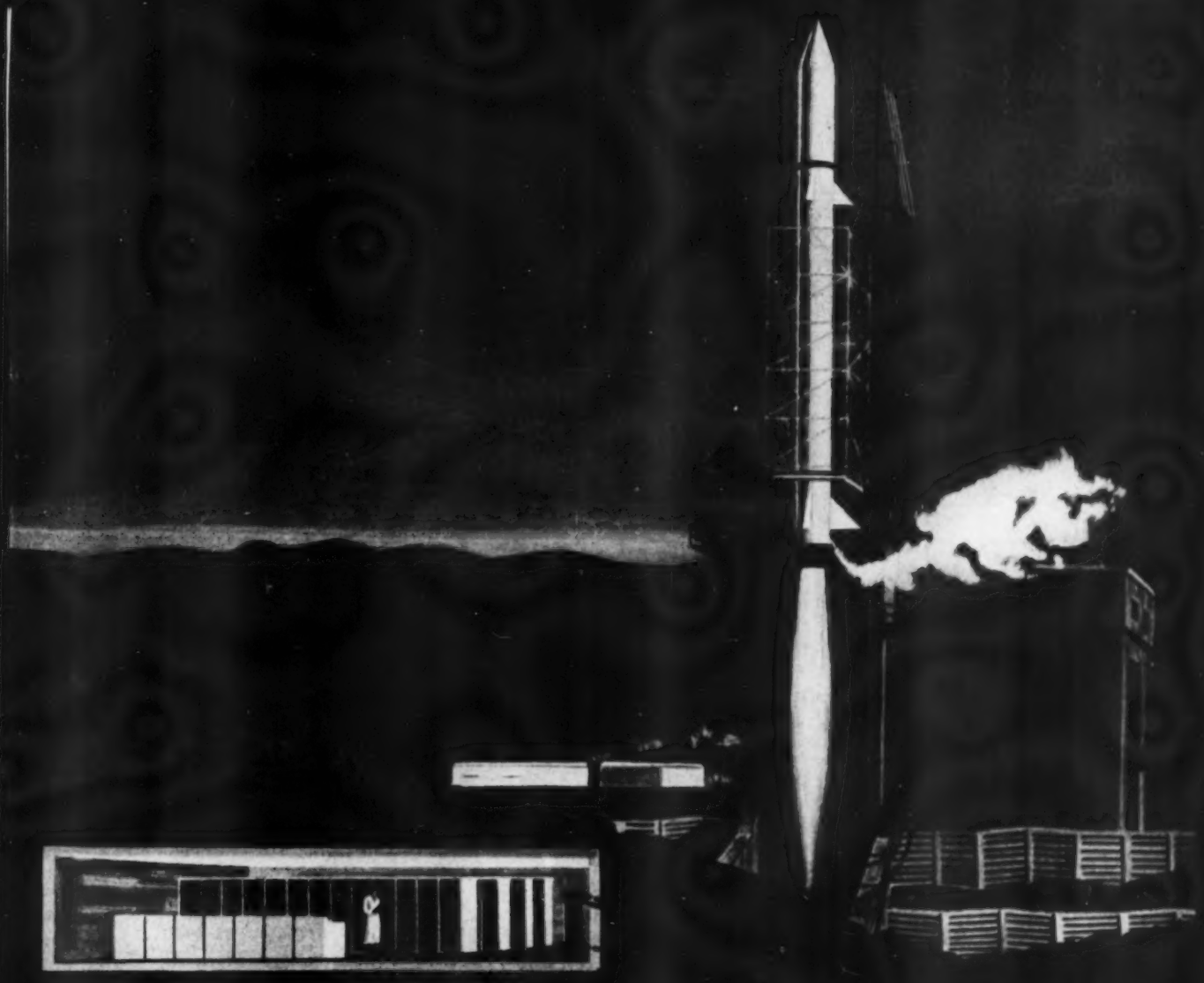

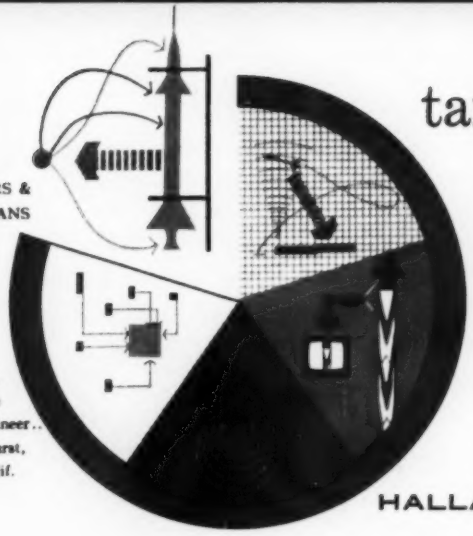

taming the big ones

"Go or no go," for some of the latest missiles in the national defense program, depends upon electronic checkout and test systems designed, manufactured, and installed by Hallamore Electronics. A major producer of missile ground support and in-flight instrumentation systems, audio and visual communications systems, magnetic products and electronic components; Hallamore performs contracts for the United States Army, Navy and Airforce, as well as for many prime companies of the aircraft and ordnance industries.

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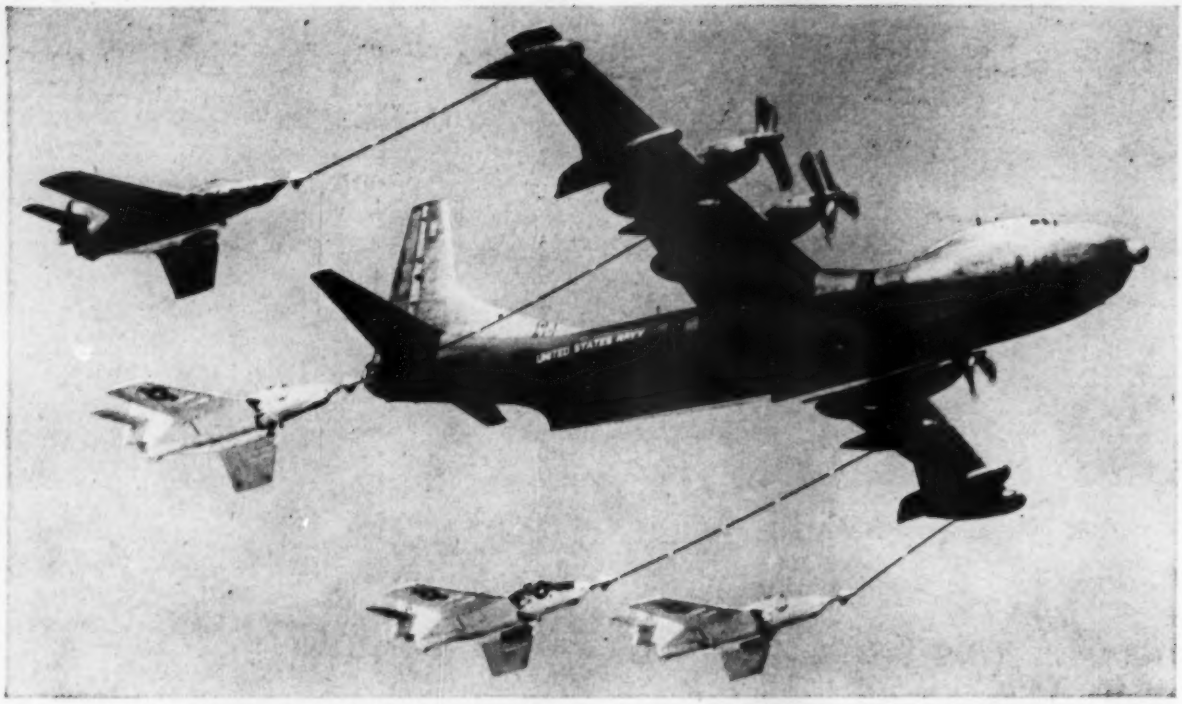


FLETCHER REFUELING SYSTEM

extends range and striking power of Navy's air arm

Here you see the Navy's Convair R3Y-2 setting a new record by refueling four jets simultaneously at a transfer rate of 1000 G.P.M. This feat was made possible through use of the Fletcher Model FR250 refueling equipment.

Secret of its success is the use of *fully automatic units* — the result of common research and development by the U.S. Navy, Convair, and Fletcher Aviation.

This aerial refueling equipment has been successfully used at speeds in excess of Mach .81 and at altitudes up to and above 30,000 feet. It is fully automatic and embodies extensive safety features.

Soon to join the Air Force are similar Fletcher refueling units with a 900 G.P.M. fuel transfer capacity — completely tested and qualified to applicable military specifications.

These systems are used in connection with auxiliary external fuel tanks of which Fletcher is the leading manufacturer. Fletcher jettisonable fuel tanks range in size from 35 to 1700 gallons capacity. At Fletcher, complete ground test facilities are available to further progress in this vital phase of long-range flight.

FLETCHER AERIAL REFUELING SYSTEM
MODEL F. R. 250

1. Operational Envelope
   - Altitude — Sea Level to 35,000 Ft.
   - Airspeed — 160 K.I.A.S. to .85 Mach.
   - Fuel Transfer Rate 200-325 G.P.M.
2. Qualification
   - Fully Qualified to Military Specifications
3. Technical Data
   - Hose Length — 105' (Max.)
   - Weight (Ex. Hose) — 380#
   - Hydraulic Powered

The above model reel has been produced in quantity and is currently operating in the R3Y-2 Airplane.

FLETCHER
aviation corporation

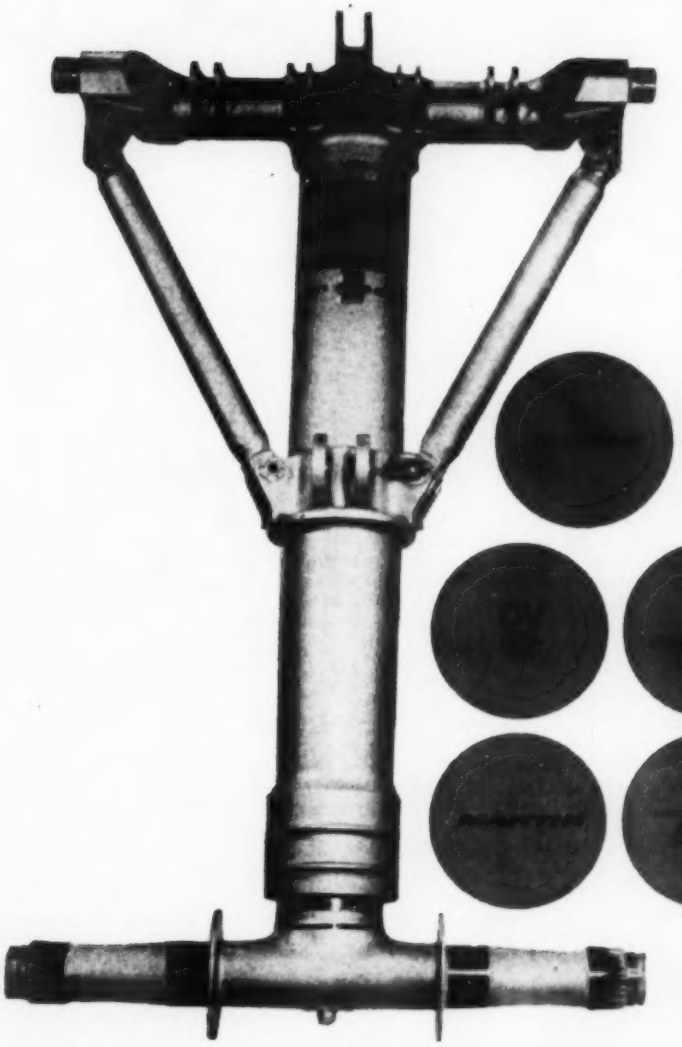
Rosemead, Calif. Dayton, Ohio

Why Choose menasco ?

...use "BLUE CHIP" *Customers*

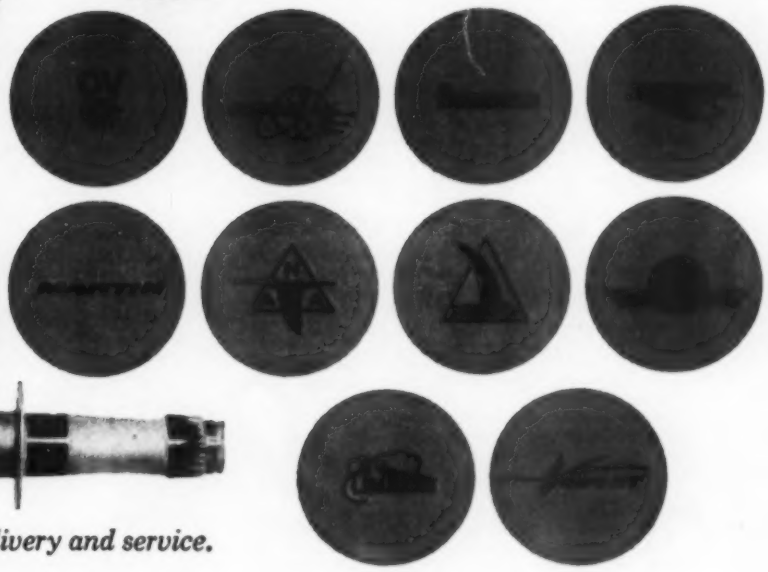
Demand "BLUE CHIP" Specialists

in Aircraft Landing Gear



MENASCO is justly proud to be closely associated with these great aircraft manufacturers. Their choice of MENASCO Landing Gear reflects their conviction that they are the very best obtainable for all types of civilian and military aircraft. MENASCO Landing Gear is adaptable to every kind of installation.

The preference for MENASCO Landing Gear to perform the vital functions of takeoff and landing is based upon a number of reasons... the exclusive *Uniwelding* process assures greater strength... MENASCO designs utilize the most effective application of high strength steels, aluminum and titanium for lighter weight and compactness. MENASCO assures *reliability* and *ruggedness* through the highest standards of quality control and thorough operational testing.



first in development, quality, delivery and service.

SPECIALISTS IN AIRCRAFT LANDING GEAR

menasco manufacturing company

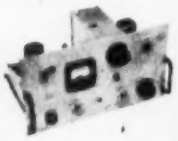
BURBANK, CALIFORNIA • FORT WORTH, TEXAS

TECHNIQUES and DEVELOPMENTS in oscillographic recording

FROM SANBORN

PHASE SENSITIVE DEMODULATOR PREAMPLIFIER PROVIDES A DC VOLTAGE PROPORTIONAL TO AN INPHASE COMPONENT OF AN AC VOLTAGE WITH RESPECT TO A REFERENCE.

The measurement of the amplitude of an AC voltage component is often necessary in performance studies of servo systems or of suppressed carrier signals over the carrier frequency range from 60 to 10,000 cps. In such cases the demodulator responds to inphase signals and rejects quadrature signals.

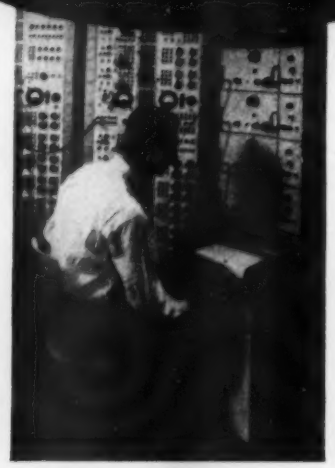


A circuit with these characteristics for use in an oscillographic recording system can be seen in the Model 150-1200 Servo Monitor (Demodulator) Preamplifier. It was developed by Sanborn as one of twelve interchangeable, plug-in front ends for "150" Series equipment, to be used with the appropriate Driver Amplifier-Power unit in any channel of a "150" system. Elements comprising the circuit from input to output, include: compensated stepped attenuator and cathode follower input circuit, phase inverter, push-pull mixer and demodulator stages, differential DC output amplifier and low pass filter. In addition, the chassis contains a VTVM to facilitate accurate adjustment of the reference voltage, and an overload indicator which lights a warning lamp when excessive quadrature voltages exist.

Adaptability to a fairly wide variety of applications is accomplished through broad input voltage, reference voltage and frequency ranges. In order, these are 50 mv to 50 v (for full scale 5 cm deflection), 10 v to 125 v; 60 cps to 10kc. Rise time with low frequency plug-in demodulation filter is 0.1 seconds; with high frequency filter, 0.01 seconds. Quadrature rejection is better than 100:1; for carrier frequencies up to 5000 cycles.

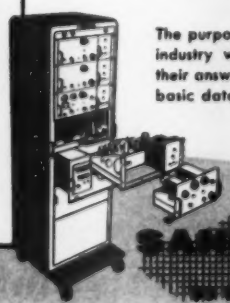
Two representative uses of the Servo Monitor Preamplifier are in the design and adjustment of servo systems, and with instruments used in the design, development or adjustment of other apparatus. The first is illustrated by use of the Preamplifier and associated equipment in the recording of the output shaft amplitude and driving frequency of an AC positional servo; the second by recordings made with a similar setup of the difference between output signals from a gyroscopically-controlled stabilizing device and the "pitch" and "roll" signals generated by a "Scorsby Table" used for testing the device under dynamic conditions.

For a detailed discussion of the principles and design considerations involved in the Servo Monitor Preamplifier, refer to the February, 1955 issue of the Sanborn RIGHT ANGLE, for Dr. Arthur Miller's article on "Measurements with the Servo Monitor Preamplifier."



BASIC FACTORS IN SELECTING OSCILLOGRAPHIC RECORDING EQUIPMENT

When considering any oscillographic system or equipment for your application, three useful "yardsticks" to apply are (1) the recording method, (2) equipment adaptability, and (3) variety of equipment available. Here are the answers to the three, as they apply to Sanborn systems. In the record, rectangular coordinates accurately correlate multiple traces, simplify interpretation and eliminate errors. Permanent traces, produced by a hot ribbon stylus without ink, provide sharp peaks and notches, and clearly reveal all signal changes. One percent linearity results from current feedback driver amplifiers and high torque galvanometers of new design; maximum error is ¼ mm in middle 4 cm of chart, ½ mm across entire chart. From the standpoints of "adaptability" and "variety", Sanborn "150" equipment offers the versatility of 13 different plug-in front ends for any basic system . . . the choice of one- to eight-channel systems . . . the variety of nine chart speeds, timing and coding controls, console or individual unit packaging . . . availability of equipment as either complete systems or individual amplifier or recorder units.



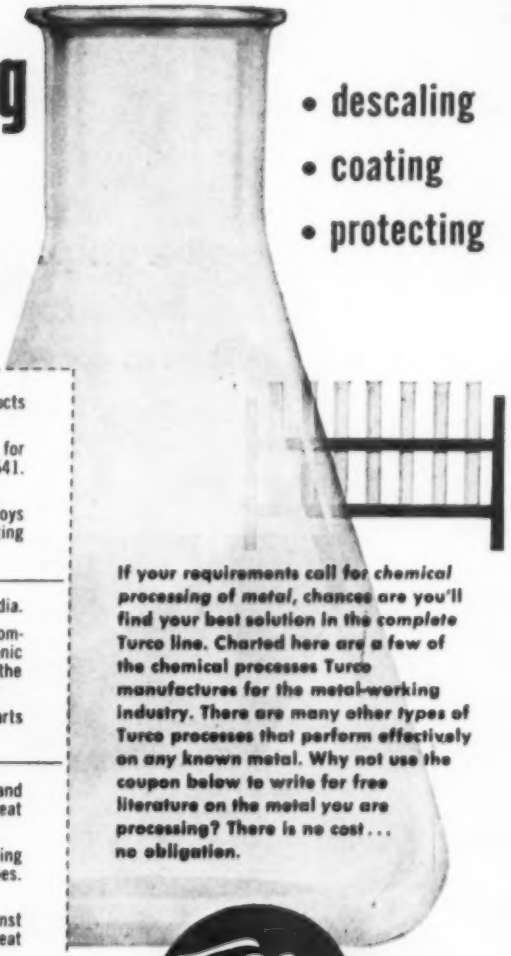
The purpose of the foregoing information is to better acquaint industry with typical oscillographic recording problems and their answers, design considerations in Sanborn equipment, and basic data on what Sanborn makes and how it is being used.

Technical literature and engineering assistance on specific problems are always available from our engineering department.

SANBORN COMPANY

FOR chemical processing OF ANY METAL... turn to Turco...FIRST!

- descaling
- coating
- protecting



ALUMINUM	**DESCALING:** Complete line of deoxidizing and polishing products for all alloys of aluminum. **COATING:** Economical and "quick fixing" conversion coating for application by spray, dip or hand methods. Approved to MIL-C-5541. Insures paint adhesion, stops aluminum corrosion. **PROTECTION:** Alkali-removable protective film for aluminum alloys both during storage (in plant and outdoor) and during fabricating practices.
STEEL	**DESCALING:** Complete line of alkaline and acid descaling media. **COATING:** Full line of iron, zinc and manganese phosphate compounds to provide a tight coating for better adhesion of organic finishes and for oil absorption. These materials all meet the various requirements of applicable government specifications. **PROTECTION:** Versatile group of products for protection of parts from the elements.
TITANIUM	**DESCALING:** Approved and accepted process for conditioning and removing scale from all current titanium alloys, both after heat forming to 1150° F. and heat treating to 1750° F. **COATING:** Acceptable anti-galling and seizing conversion coating for the major alloys of titanium. Also used as base for lubes. Requires no post-heat treatments. **PROTECTION:** Easily removable coating to protect titanium against tightly adhering scale up to 1600° F. during hot forming or heat treating.
STAINLESS STEEL	**DESCALING:** Process for completely removing heat scale from various alloys (including 17-7 PH). **COATING:** Easily removable coating to protect stainless steel against tightly adhering scale up to 1600° F. during hot forming or heat treating.
MAGNESIUM	**DESCALING:** Non-electrolytic alkaline process for removing previous chrome pickle films as well as oily substances often found on magnesium. **COATING:** One-package powdered product which, when in solution with water, replaces Dow #17 treatment. Requires no mixing of chemicals. Eliminates chance of human error. **PROTECTION:** Single-package touch-up liquid to produce coatings equal to Dow #18 treatment. (Note: All magnesium processes mentioned above are approved for use by Magnesium Department, Dow Chemical Co.)

If your requirements call for *chemical processing of metal*, chances are you'll find your best solution in the *complete* Turco line. Charted here are a few of the chemical processes Turco manufactures for the metal-working industry. There are many other types of Turco processes that perform effectively on any known metal. Why not use the coupon below to write for free literature on the metal you are processing? There is no cost... no obligation.

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For Cleaning or Metal Conditioning Problems—Turn to Turco ...First!

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Titanium ____ Stainless Steel ____ Magnesium ____

Steel ____ Aluminum ____ Other (specify) ____

NAME ____

TITLE ____

AW

Leadership: Avionics Design and Packaging

GROUND COMMUNICATION

Collins engineers designs and supplies the equipment, installs and puts into operation integrated point-to-point communication systems of any scope. The Collins system engineering staff is backed by the finest equipment in the world, whether standard MF, HF or VHF, Transhorizon scatter, microwave relay and multiplex or single sideband HF. Typical of Collins communication progress is Kineplex — a high speed data transmission system doubling communication capacity.

AMATEUR RADIO

In the early 1930's Collins set the standard of Amateur radio and through continuous development has used this standard to its present single sideband station — the most honored and prized in the Amateur fraternity. This station is the top performing unit on the air with its famous KWS-1 transmitter and highly selective 75A-4 receiver. Many of the leaders in the electronics industry became acquainted with Collins through the Collins Amateur equipment.

Collins

CNI

Communication
Navigation
Identification

Collins CNI is an efficient electronics package designed to each aircraft type and provides a common logistics base by utilizing identical modules for all aircraft.

Advanced packaging techniques plus increased attention to problems regarding vibration, heat transfer and mutual interference have led to development of the Collins-designed AN/ASQ-19 Integrated Electronics System.

McDonnell Aircraft Corporation, first to use this design, has been instrumental in proving and refining the system.

BROADCAST

Collins supplies a complete new AM station from mike to antenna or modernizes existing facilities. Besides the superior line of transmitters, Collins satisfies the broadcaster's needs with such advanced additions as TV STL microwave relay system, the lightest 4 kilowatt remote amplifier on the market, phasing equipment and audio consoles. Collins also serves broadcasters with an engineering staff of experts assisting the broadcaster in every phase of planning.

COMPONENTS AND TEST EQUIPMENT

The degree of precision and reliability of Collins products requires development by Collins engineering of components such as Autotunes and Autosyncros, Mechanical Filters, oscillators, heat reducing tube shields and ferrites. These developments and other high quality components are sold by a Collins subsidiary, Communication Accessories Company of Hauppauge, L.I., New York. The same principles of accuracy and reliability apply to Collins test equipment, built especially for Collins but adaptable to testing other equipment types.

COLLINS

86% of your welding costs are in labor and overhead...

P&H

welding positioners can slice that in half!

The greatest savings you can realize in your welding operation lie in how you *handle* your weldments.

Are your operators waiting for cranes . . . rolling heavy weldments laboriously by hand . . . welding in awkward, tiring positions that affect both operator efficiency *and* weld quality? These are the factors that send labor and overhead costs skyrocketing. These are the factors that account for 86¢ out of each welding dollar, however, we'll show you how the use of P&H Welding Positioners frequently cut this cost *in half*.

Interested? Of course you are. Write for the facts. Address: W R. Stephens, Sales Manager, Dept. 303-H Welding Division, Harnischfeger Corp., Milwaukee 46, Wis.

Photo courtesy Lakeside Bridge & Steel Co., Milwaukee, Wisconsin.

All standard P&H welding positioners give full elevation even under capacity load. 360° rotation, 135° tilt.
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engineering

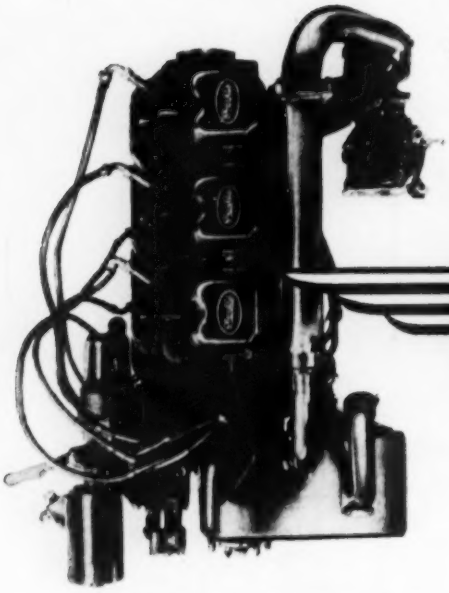
now available in a

"package"

from Twin Coach

First step in '57 toward improved altitude and payload performance

...the new, more powerful



Franklin 210

Now in production is the new Franklin "210", offering dramatic increases in performance for many helicopters now flying with earlier Franklin engines.

The new "210", with 210 h.p. sea-level rating, maintains a full 200 h.p. at 1500 ft., yielding substantial dividends in payload in mountain or "high country" operations. Hot weather operations are similarly benefited, with 200 h.p. maintained at 110° F.

With 5% additional power, the Franklin "210" actually weighs slightly less than the Franklin "200" now installed in several thousand helicopters, yet it develops its higher output at the same 3100 r.p.m. The potential increase in payload is approximately 12½%.

Existing Franklin "200" engines can be modified to produce the new 210 h.p. rating at moderate cost. Or a new "210" is interchangeable with your present Franklin engine installation. Write for complete details.

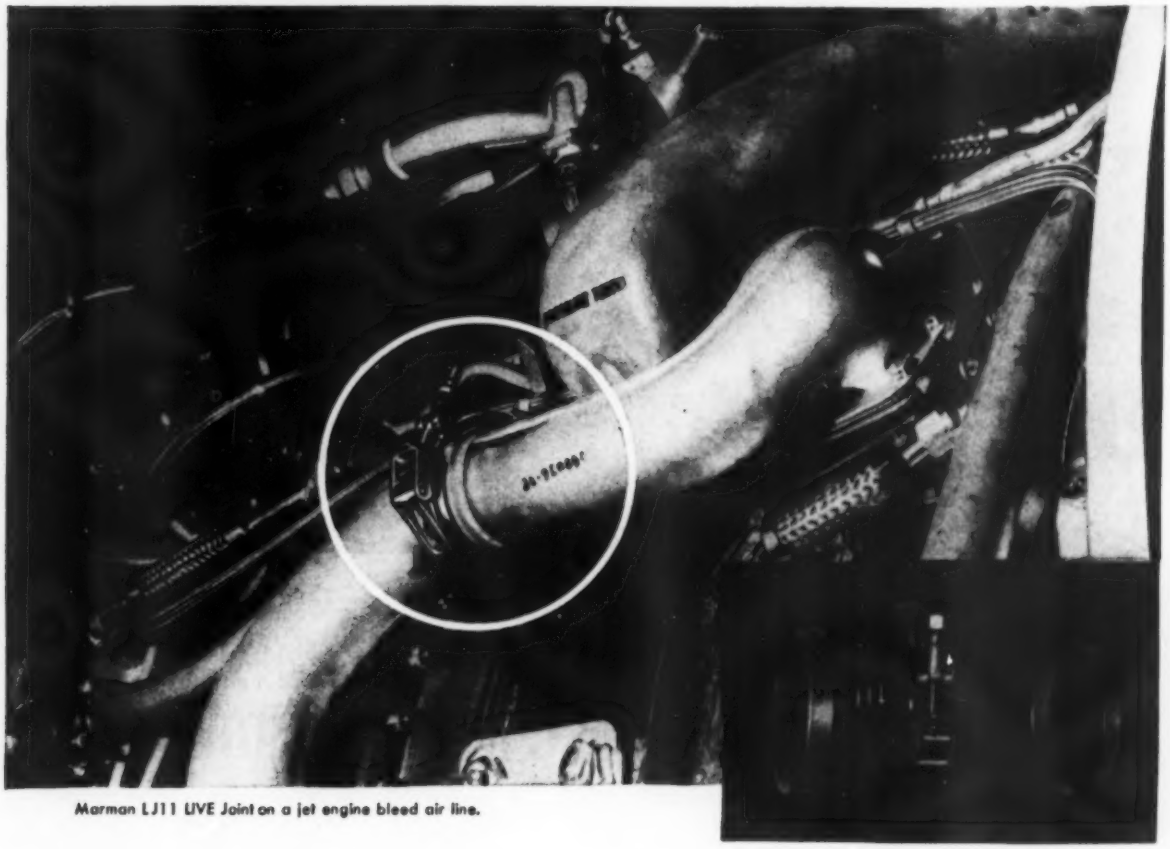
Watch Franklin for more news of great new developments in helicopter power in 1957.

Aircooled Motors

AIRCOOLED MOTORS, INC., SYRACUSE, N. Y.

Smith, Kirkpatrick & Co., Inc., 47 Beaver Street, New York 4, N. Y. • Export Distributors of "Aircooled" Products • Cable Address "Kirksmith"

Marman LIVE Joint Systems Speed Connection-Disconnection of Aircraft Tubing



Marman LJ11 LIVE Joint on a jet engine bleed air line.

Marman J11 and LJ11 LIVE Joints are designed to connect AND10104 tubing and maintain a positive seal over a wide range of temperatures and pressures. When deflections are imposed on the joint by pressure loads or thermal stresses, the wedging action of the V-band coupling against the flange faces retains the metal-to-metal seal.

Compact configuration of high performance Marman LIVE Joints makes them superior to bolted flanges and B-nuts where installation accessibility and weight savings are desired. J11 and LJ11 Joints are available in O.D. tube sizes from 1" to 12". Temperature range is —300°F. to —1000°F., for pressures up to 2000 psi. Write for full information.

MARMAN DIVISION
Aeroquip Corporation

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MARMAN PRODUCTS ARE MANUFACTURED UNDER VARIOUS U.S., CANADIAN AND FOREIGN PATENTS AND OTHER PATENTS PENDING

ACTUAL SIZE

LIGHTER, SMALLER ADF WITH GREATER ACCURACY, HIGHER SENSITIVITY

NEW, COMPACT BENDIX DFA-70 HAS INCREASED EFFECTIVE RANGE, ELECTRICAL TUNING, FLUSH-MOUNTED ANTENNA

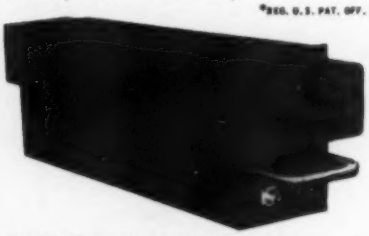
Bendix* ADF—long the "standard of the industry"—reaches another new high in performance and reliability with this new, improved DFA-70 system. Covering all frequencies from 90 to 1750 kilocycles, it provides both visual and aural navigation information, including narrow-band Consol reception. And with the greater accuracy and higher sensitivity that have been built into the system, a significant increase in operating range is obtained.

One of the important features of this new system is the electrical tuning which permits the Control Panel to be located as far as 50 feet from the receiver. In the design of the DFA-70 Control Panel, shown above, human engineering principles have been used to make tuning fast, easy and precise. Frequency knobs are labeled for quick identification; panel markings are large and easy to read; location of controls on the panel is planned for maximum accessibility.

Another important feature is the newly designed flush-mounted loop antenna. With this new unit, precipitation static is greatly reduced and drag is completely eliminated.

For complete information and specifications about the DFA-70, write Bendix Radio Division, Aviation Electronic Products, Baltimore 4, Maryland. Or West Coast—10500 Magnolia Boulevard, North Hollywood, California; Export—Bendix International Division, 205 East 42nd Street, New York 17, New York.

*REG. U.S. PAT. OFF.



½-ATR DFA-70 RECEIVER features sub-chassis construction, ARINC Class 1 ruggedized tubes, improved circuitry for minimum power consumption.

Bendix Radio Division

Bendix AVIATION CORPORATION

First in development and manufacture of advanced aircraft accessories, Simmonds offers the U. S. aviation industry a proved source for specialized electronic, hydraulic and mechanical components and systems.

SIMMONDS PRECISION PRODUCTS

ELECTRONIC • HYDRAULIC • MECHANICAL

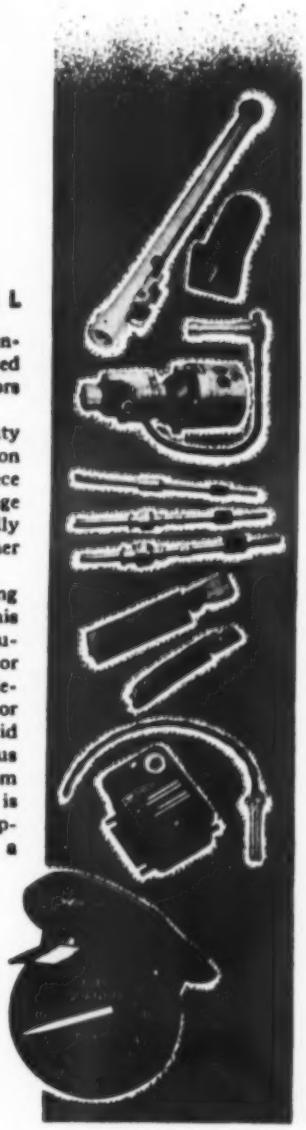
Lightweight Pacitron Fuel Gage Systems: Fuel measurement and fuel management systems incorporating latest technological improvements are available in the famous Pacitron systems. Consistent reliability and dynamic progress are typified by the Load Limit Control, the Center of Gravity Control and the new True Mass Fuel Gaging System. Specification of Pacitron in the latest military and commercial aircraft emphasizes Simmonds' continued leadership in the field.

Simmonds SU Fuel Injection Systems: The only advanced type fuel injection system now in production for medium h.p. gasoline engines, the SU System has been proven in field tests to give economies up to 25%. Eliminates icing problems, and gives improved cold starts.

Precision Push-Pull Controls: Simmonds Push-Pull Controls are positive, precise and rugged. Capable of heavy loads and accurate operation under vibration, continuous cycling, temperature extremes, etc. Proved in millions of miles of service on aircraft engines, pressurized doors, and specialized applications such as temperature actuators and afterburner control systems.

Cowling and Access Latches: Heavy duty flush fitting aircraft latches for installation on cowlings and access panels. Two-piece toggle type, available to fit a wide range of structural curvatures. Used successfully for attachment of plastic radomes and other detachable structures.

Liquid Level Sensing Systems: Working independently of the fuel gage system, this thermistor sensing system indicates accurately the precise time at which fuel, oil or other liquid goes above or below any designed level. It also automatically stops or starts pumps or valves to transfer the liquid from one tank to another. Settings at various levels are easily accomplished. The system is rugged, has no tubes or moving parts, is light and compact, simple, dependable. Operates on military aircraft fuels, oils and a wide variety of other liquids.



Detailed literature available on all the above products

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WELDING PROGRESS REPORT

Production Line Experience Proves the Consistency of New Sciaky Electronic Weld Control

First reports from aircraft industry manufacturers are unanimous in their recognition of the absolute weld consistency and positive reproducibility provided by the new Sciaky Predetermined Electronic Counter controlled welders.

Users say that, for the first time, it is now possible to get *precisely* what they set on the welder. The machine cannot deviate from its setting. It is consistent throughout the entire range of adjustment. And set-up to repeat previous production runs is simple and positive.

How It Works

Without deviation, the new Sciaky control counts the cycles of power line frequency which is governed by the U.S. Naval Observatory. In predetermined absolute numbers, cycles and impulses are simply counted by a Dekatron tube to control the duration of various welder functions.

Single Tube Handles All Succeeding Functions

A single tube is used to count both the respective cycles of succeeding functions as well as impulses of welding current. For example, only one Dekatron tube is used to count respective cycles of squeeze, weld, hold and off and in respective impulses, preheat, weld and postheat. A second Dekatron tube is needed only for simultaneous functions, such as cool, heat, and current decay.

All control dials for timing functions are calibrated in cycles, while all control dials for interval functions are calibrated in impulses of secondary current. No involved second-to-cycle calculations are required for welder set-up.

Simple Maintenance

Plug-in sub-assembly control units minimize maintenance down-time. Replacement of a sub-assembly is only a matter of minutes.

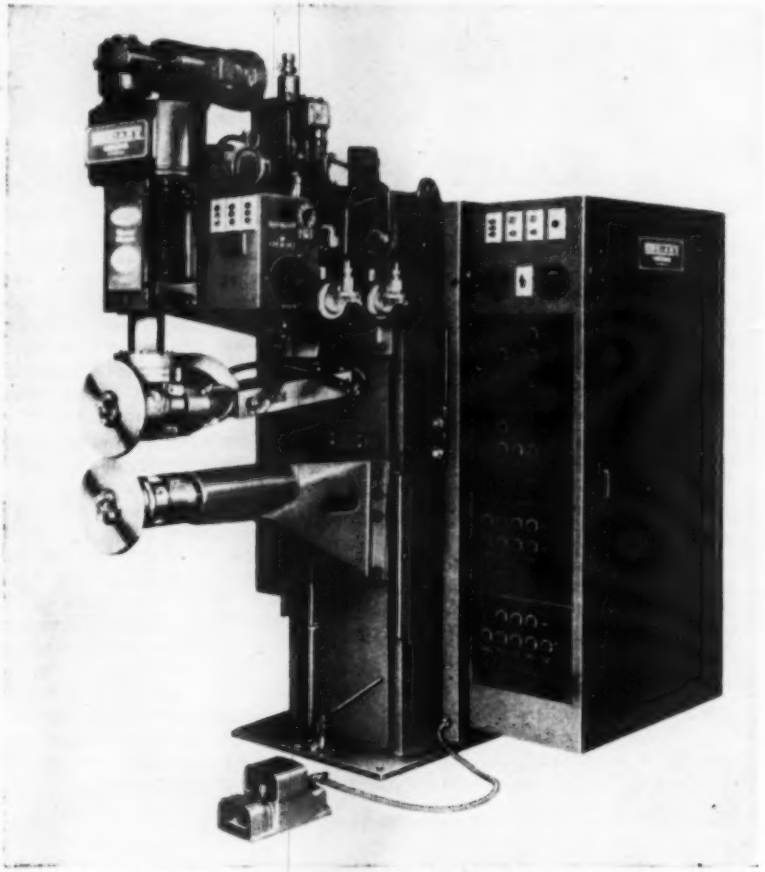
The absolute consistency of the control eliminates the need for time consuming periodical check-out or calibration.

Future applications of the machine that may require additional welder functions won't obsolete the welder. The plug-in sub-assembly feature permits easy addition of preheat, quench, postheat, etc.

Data Available

More complete information on operation and control combinations available with Sciaky Predetermined Electronic Counter controlled welders is given in Sciaky Bulletin No. 339. Copies are available on request.

At regular intervals Sciaky will present reports of jobs being done on Predetermined Electronic Counter controlled welders. Look for them in leading aviation industry magazines.

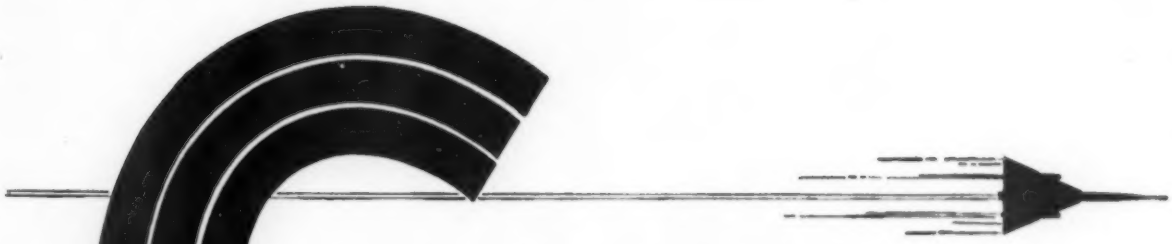


PMM 2 STK 125 KVA ROLL SPOT AND SEAM WELDER with Predetermined Electronic Counter Weld Control.

Largest Manufacturers of Resistance Welding Machines in the World

SCIAKY.

Sciaky Bros., Inc., 4935 West 67th Street, Chicago 38, Ill., Portsmouth 7-5600



In the Aircraft Industry...

Solar is Synonymous with Stainless Steel

EXPERIENCE Solar has more experience in building airframe and engine components of stainless steels, titanium, and other advanced metals and high alloys than any other company in the world.

DESIGN Solar can greatly assist you in the design of components and assemblies to be built of high alloys—because of Solar's intimate knowledge of the problems and possibilities of these special metals

DEVELOPMENT Solar is being asked to undertake more and more basic development projects in association with other companies—because of Solar's unique skills with advanced metals and their engineering.

MANUFACTURE Two large plants offer strategic dispersion with integrated, experienced management. Solar's production record is unmatched for quality, service, dependability, and prompt delivery.

FOR MORE INFORMATION ABOUT SOLAR'S CAPABILITIES, WRITE DEPT. C-138, SOLAR AIRCRAFT CO., SAN DIEGO 12, CALIFORNIA.

SOLAR
AIRCRAFT COMPANY

SAN DIEGO
DES MOINES

Designers, Developers and Manufacturers • Gas Turbines • Aircraft and Missile Components • Bellows • Controls • Coatings • Metal Alloy Products

No time now for battery failure. Plane's on the ramp... waiting for clearance... engines are idling...

GUARD AGAINST TAKEOFF DELAY

Silvium resists corrosion

Silvium alloy grid after corrosion test.

Non-Silvium alloy grid after same test.

New Exide Batteries with Silvium grids prove far safer against sudden failure

Don't expect any warning when a battery fails from grid corrosion. The end is sudden—and costly for the airline when it delays plane takeoff.

But now Exide introduces a new line of batteries aimed at eliminating this risk. The secret is Silvium alloy grids—proved so resistant against corrosion they outlast the battery. Silvium is exclusive with Exide Batteries.

New features also include quick-responding GOX active material and long lasting Pormax separators. For complete facts, call your nearby Exide sales office, or write Exide Industrial Division, The Electric Storage Battery Company, Phila. 2, Pa.

Exide®

The first Pantobase BLC transport

The usefulness of military transport aircraft has been extensively increased with the introduction of the Stroukoff C-134. Produced for the United States Air Force this rugged heavyweight requires extremely short take-off and landing runs and can operate from any surface—land, sand, ice, water, etc. Advanced airframe design has been combined with Stroukoff Pantobase and Boundary Layer Control Systems to produce a new type of aircraft equipped for a variety of assault and logistic missions requiring operation without the limitation of conventional runways.

The Stroukoff C-134 is destined for an important role in modern military strategy.

Interesting opportunities for qualified engineers in many fields exist at Stroukoff.

Extending the Frontiers of Aircraft Performance

Stroukoff AIRCRAFT CORP.

WEST TRENTON, N. J.

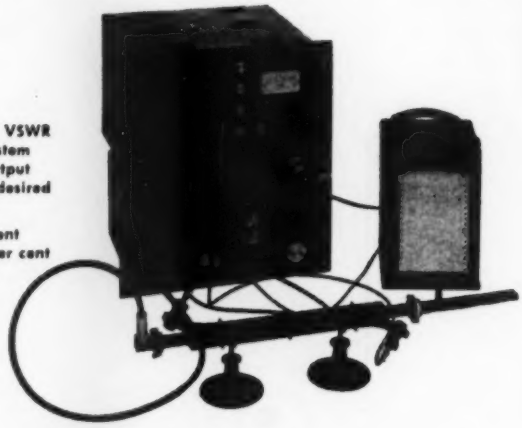
Specialized TEST INSTRUMENTS

AUTOMATIC TESTING WITH THE Supertester®

Versatility and high speed bring automation to the quantity testing of electronic and electrical equipment. Continuity, leakage, resistance, impedance, a-c voltage, and d-c voltage tests can be made in any combinations. The flexible test program can be changed rapidly to meet the needs of a wide variety of circuits. Available for rack mounting or in the standard model shown.

MEASURE—RECORD

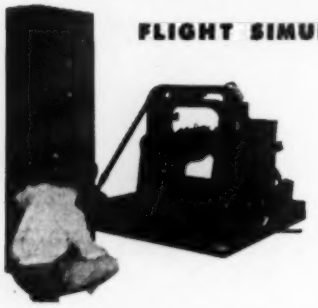
X-BAND SWEEP VSWR SYSTEM



For instant, continuous observation and plotting of broadband VSWR characteristics, the CTI Sweep-Frequency VSWR Measuring System provides integral oscilloscope and meter presentation and output for recorder. The instrument automatically sweeps all or any desired segment of the 8,500 to 9,600 mc range.

Special reflectometer measuring techniques in the CTI instrument provide advantages of a unique overall system accuracy of 2 per cent and extremely high speed compared with slotted-line methods.

FLIGHT SIMULATORS



For complete flight-control-system evaluation, two CTI instruments provide facilities for 1) reproduction of the three positional and rotational rates which represent flight conditions and 2) the dynamic altitude-pressure variations encountered over the altitude range —1,000 ft to 80,000 ft.

Three-Axis Simulator gives accelerations of 40,000 deg/sec^2 in roll, 8,000 deg/sec^2 in yaw, and 20,000 deg/sec^2 in pitch. Dynamic Altitude Simulator has frequency response of 10 cps and bandwidth ±700 ft in altitude.

LOG-LINEAR AMPLIFIER

Designed for use in antenna pattern recording systems, the Logarithmic Linear Amplifier permits the use of conventional recording meters in plotting log functions on a linear scale. The input provides bias current for bolometer operation and will also accommodate crystal detectors.

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CTI maintains an unusually versatile group of engineers with a comprehensive background in the design and development of electronic equipment.

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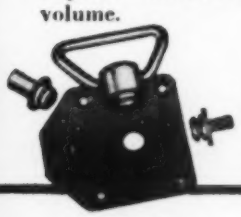
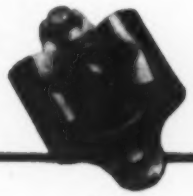


WEDJIT
Seat and Cargo
Tie-down Fastener



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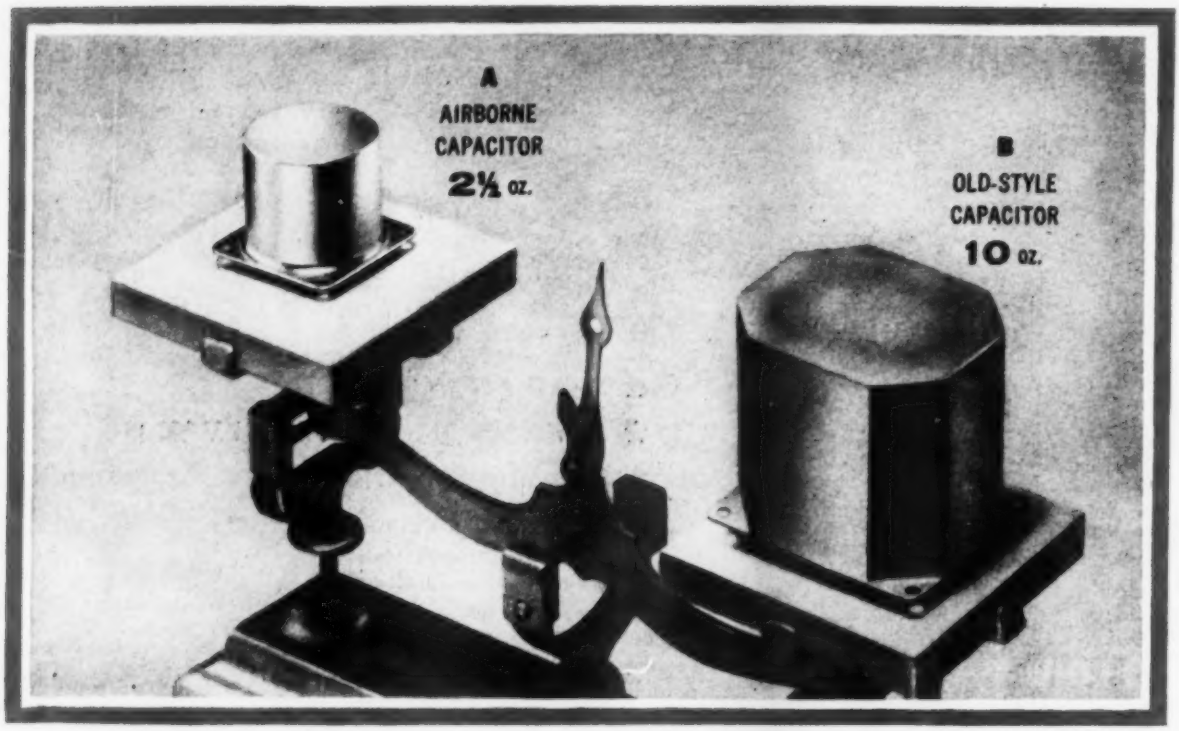

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We got into the custom capacitor and r.f. filter business because we wanted lighter, smaller, more efficient capacitors and filters for our aircraft motors and couldn't find any. So we began making our own.

Using Mylar dielectric and a special conductor, we have been able to make dramatic reductions in capacitor size and weight, while maintaining or increasing capacity and dielectric strength. The example above is typical.

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Send for quotations on Airborne custom miniaturized capacitors — and Airborne miniaturized r.f. filters.

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Dimensions ...	1¼ x 1½ in. diam.	2 x 2½ x 2¼ in.
Capacity	9.5 mfd ±10%	5 mfd ±10%
Dielectric	Mylar	Paper
Dielectric Strength	1500 v	500 v
Weight.....	2.5 oz.	10 oz.
Temp. Range..	—65° to +300°F.	—65° to +160°F.

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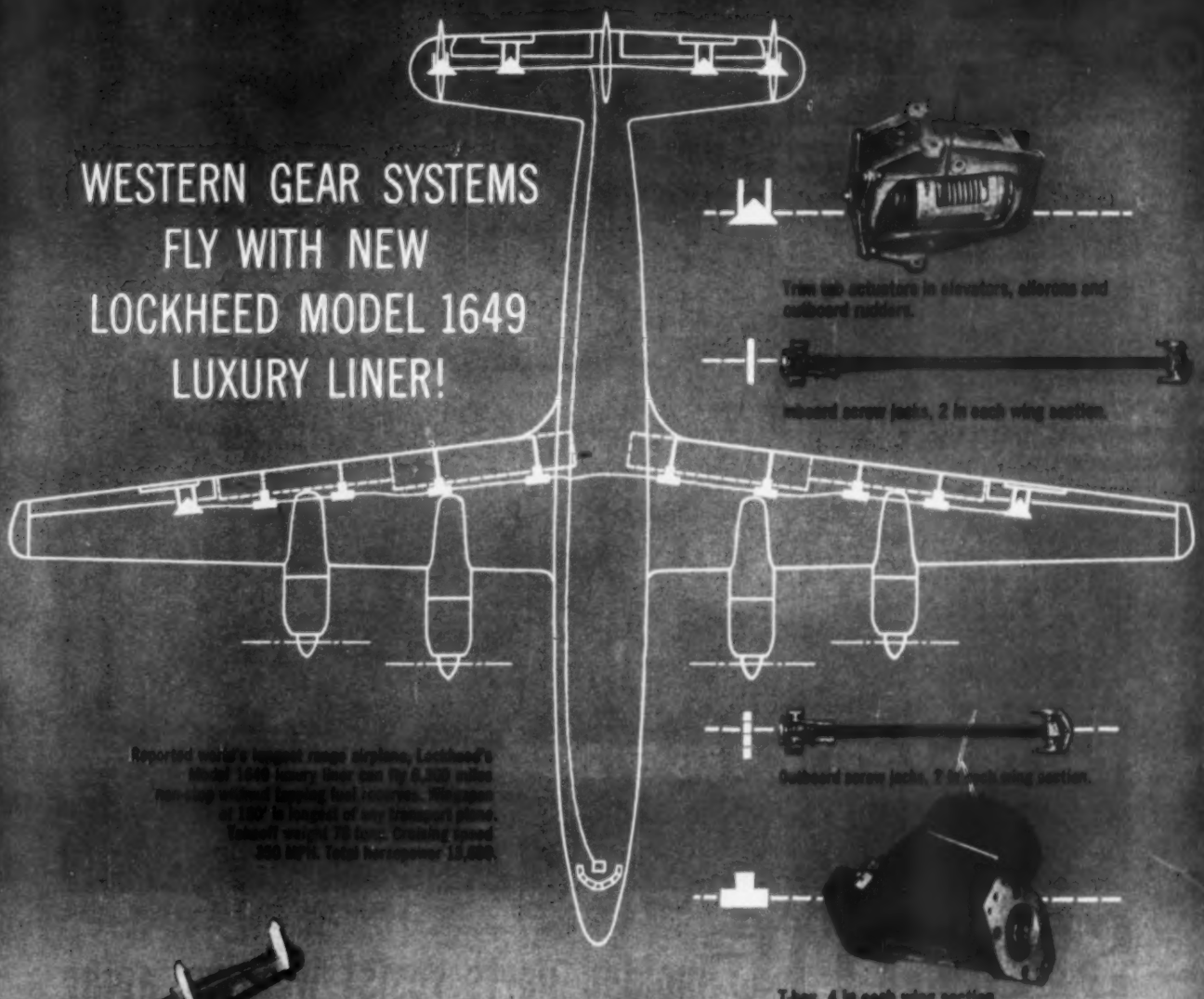
WESTERN GEAR SYSTEMS FLY WITH NEW LOCKHEED MODEL 1649 LUXURY LINER!



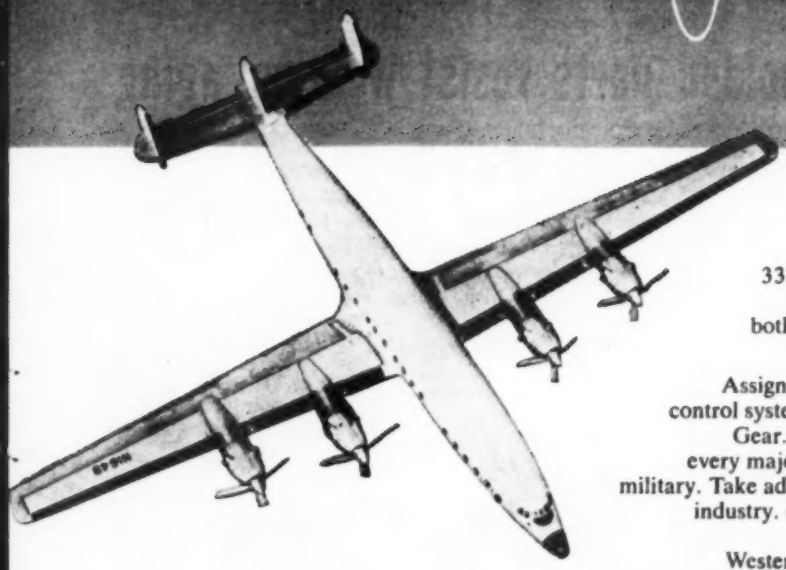
Trim tab actuators in elevators, ailerons and outboard rudders.

Inboard screw jacks, 2 in each wing section.

Outboard screw jacks, 2 in each wing section.

T-box, 4 in each wing section.

Reported world's longest range airplane, Lockheed's Model 1649 luxury liner can fly 6,500 miles non-stop without flipping fuel reserves. Wingspan at 150' is largest of any transport plane. Takeoff weight 70 tons. Cruising speed 360 MPH. Total horsepower 15,680.



Western Gear's wing flap system on Lockheed's newest and largest luxury liner, Model 1649, using ball screws to actuate 335 sq. ft. of wing flap area, helps in takeoff and landing. Western Gear trim tab controls on both outboard rudders, elevators and ailerons aid in maintaining steady, true flight.

Assignment to design and construct such important control systems is evidence of Lockheed faith in Western Gear. Western Gear equipment is aboard virtually every major aircraft flying today, both commercial and military. Take advantage of 40 years of service to the aviation industry. Call on a Western Gear aircraft specialist for recommendations. Address General Offices, Western Gear, P.O. Box 182, Lynwood, California.

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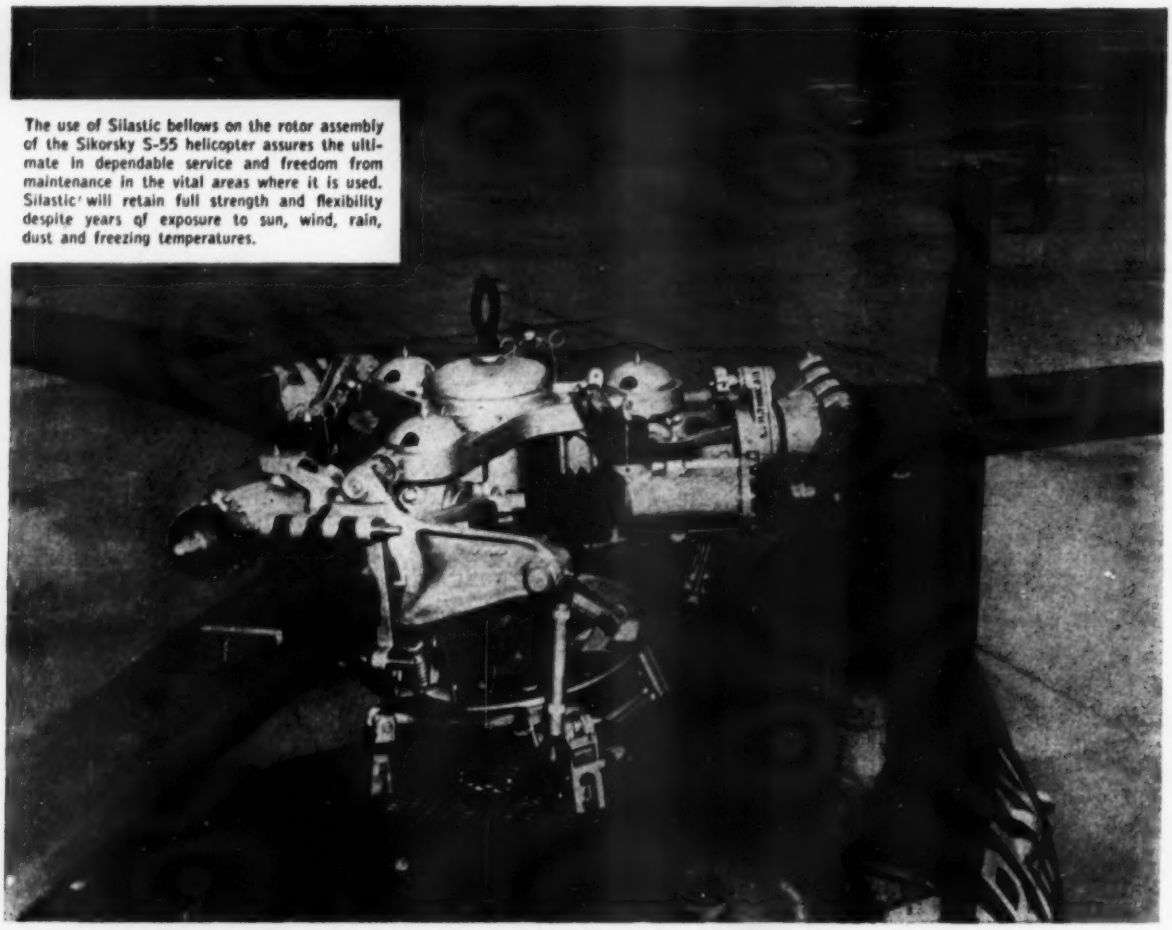

The use of Silastic bellows on the rotor assembly of the Sikorsky S-55 helicopter assures the ultimate in dependable service and freedom from maintenance in the vital areas where it is used. Silastic* will retain full strength and flexibility despite years of exposure to sun, wind, rain, dust and freezing temperatures.

SILASTIC molded parts resist weather aging

Molded parts of Silastic*, Dow Corning's silicone rubber, show little or no change in original physical strength, hardness and flexibility after long exposure to grueling weather conditions which would quickly ruin organic rubber. Leading rubber companies will supply Silastic molded parts in practically any color, size or shape.

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• Elongation, %	150 to 300
• Compression set, %, @ 300 F	15 to 40
• Hardness range, durometer	20 to 90
• Dielectric strength, volts/mil	400 to 500
• Oil resistance	Dependent on type of oil

If you consider ALL the properties of a silicone rubber, you'll specify SILASTIC.

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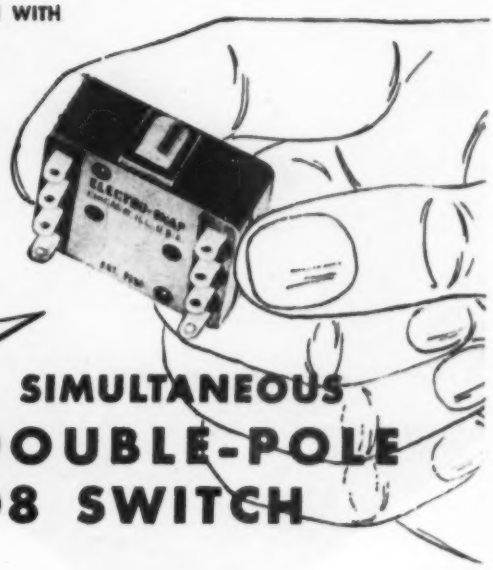
- **THE SMALLEST DOUBLE-POLE SWITCH.**
  Saves weight and space; allows more compact designs.



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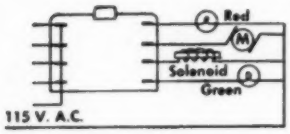
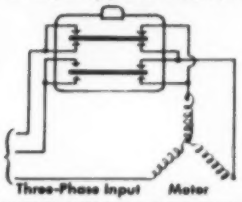


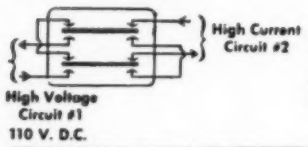
Used in motor control device at left, switch, when actuated, (1) turns off red pilot light; (2) completes circuit to motor winding, starting motor; (3) opens circuit to solenoid latch; locking door to motor gear box; and (4) turns on green pilot light.

Start, Stop, Reverse Three-Phase Motors



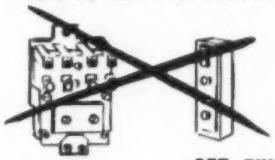
Because this new double-pole switch can simultaneously break or reverse current flow through *two* windings of a three-phase motor, you can use it as an inexpensive limit switch on three-phase lathes and drills. Use it to control automatic sequences, to limit motion of machine members driven by three-phase motors and as a start-and-stop switch.

Wire Movable Poles in Series to Switch High Current or High Voltage



As proof of simultaneous action, you can connect the two movable poles in series to increase contact area for high current applications and to increase number of contact breaks for high voltage switching.

Eliminate Expensive Relays and Additional Switches in Many Applications



This double-pole switch offers designers a wide variety of circuit hook-ups that were formerly possible only with complicated relays or a number of separate switches. Controlling three-phase motors is but one example.

Equip with Actuator

Push-button actuator may be added for panel mounting or for long overtravel. Switch is rated at 15 amps 125/250 v. AC or 10 amps inductive, 30 v. DC. Case dimensions are only 1½" x ⅞" x ½". Weighs only 20 grams.

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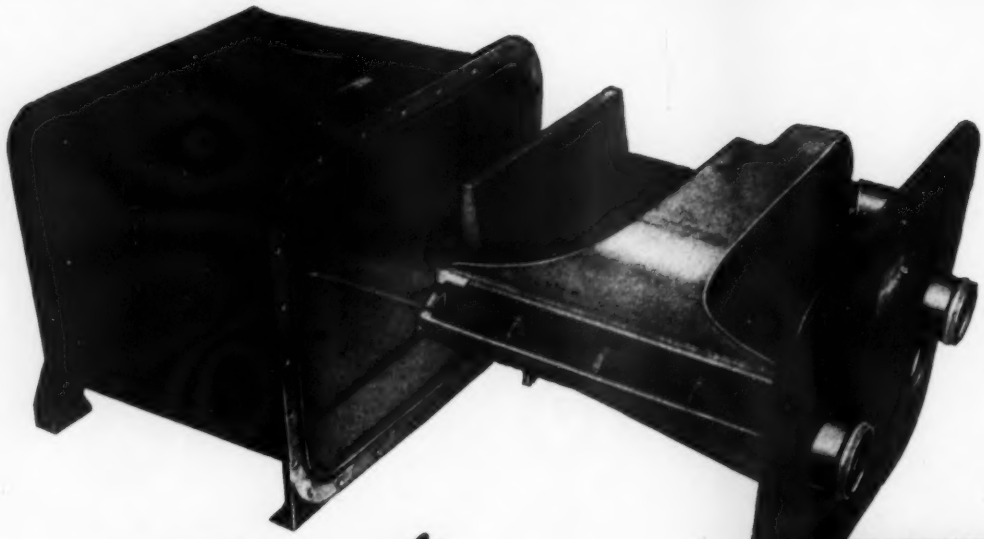

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**Unit shown designed by Ohio State University Research Foundation —Air Force Cooling Study Project, W. Robinson, Supervisor.*

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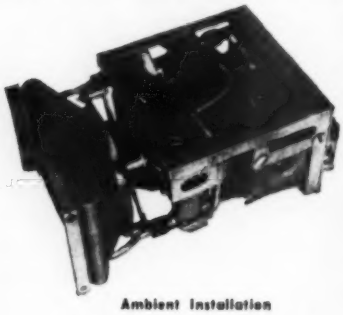
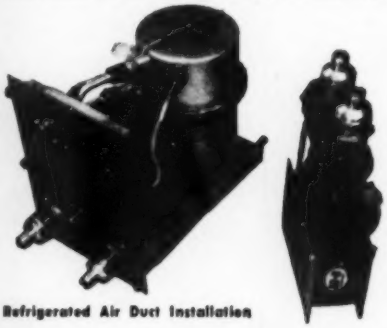


Ambient Installation



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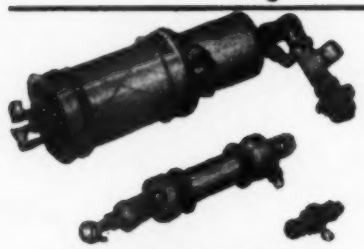
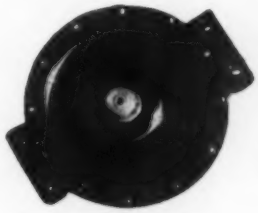
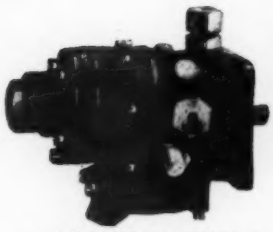


1 SPECIALIZED HYDRAULIC COMPONENTS



2 VISCOUS SHIMMY DAMPER

3 LINEAR ROTOR BLADE LAG DAMPER

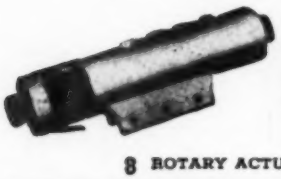


4 HYDRAULIC PUMPS

5 ROTARY SHIMMY DAMPER

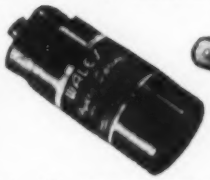
6 FLUTTER DAMPER

7 NOSE WHEEL STEER DAMPERS



8 ROTARY ACTUATORS

9 ROTARY DAMPERS



10 HYDRA SPRING

11 LINEAR FLUTTER DAMPER

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3 **LINEAR ROTOR BLADE LAG DAMPER**—For all rotor blade and swash plate applications.

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5 **ROTARY SHIMMY DAMPER**—For use on nose and tail wheels, outrigger gear, and helicopter landing gear.

6 **FLUTTER DAMPER**—For all control surface vibration applications. May also be utilized as a combination damper-rotary actuator.

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10 **HYDRA SPRING**—A precision hydraulic device using compressibility of liquids to produce unusually efficient and highly effective spring and/or damping actions.

11 **LINEAR FLUTTER DAMPER**—For use in applications when linear motion is required to meet limiting envelope restrictions.

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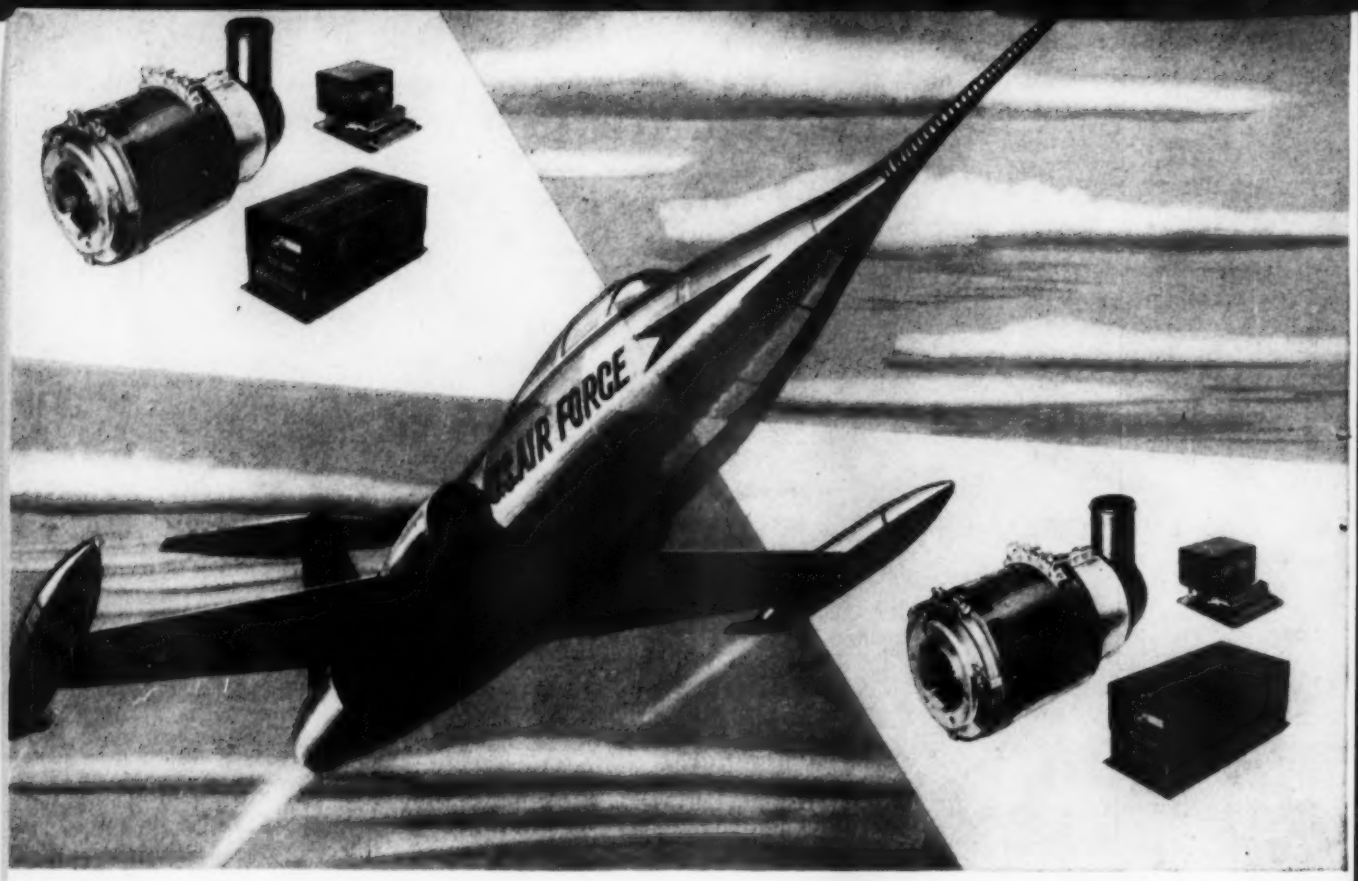

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The Bendix AC generator setup aboard the F-104 is a *dual* system, with either system able to handle the entire electrical load alone, if necessary. Developed by Bendix Red Bank Division, the system has many advanced features and advantages (see adjoining column) that enable it to answer the many difficult problems arising from the complex needs of an airplane that can climb with the speed of sound.

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AC

AIRCRAFT SPARK PLUGS

WHEN YOU TURN ON THE SCOPE TO GET THE INSIDE DOPE, YOU GET A PERFECT PICTURE!

From run-up to take-off to landing, including intermittent checks, the Ignition Analyzer gives graphic proof of AC reliability. Check them all, bank by bank or one at a time—you'll find that AC-285 *Fine Wire* Aircraft Spark Plugs come through with flying colors on the scope!

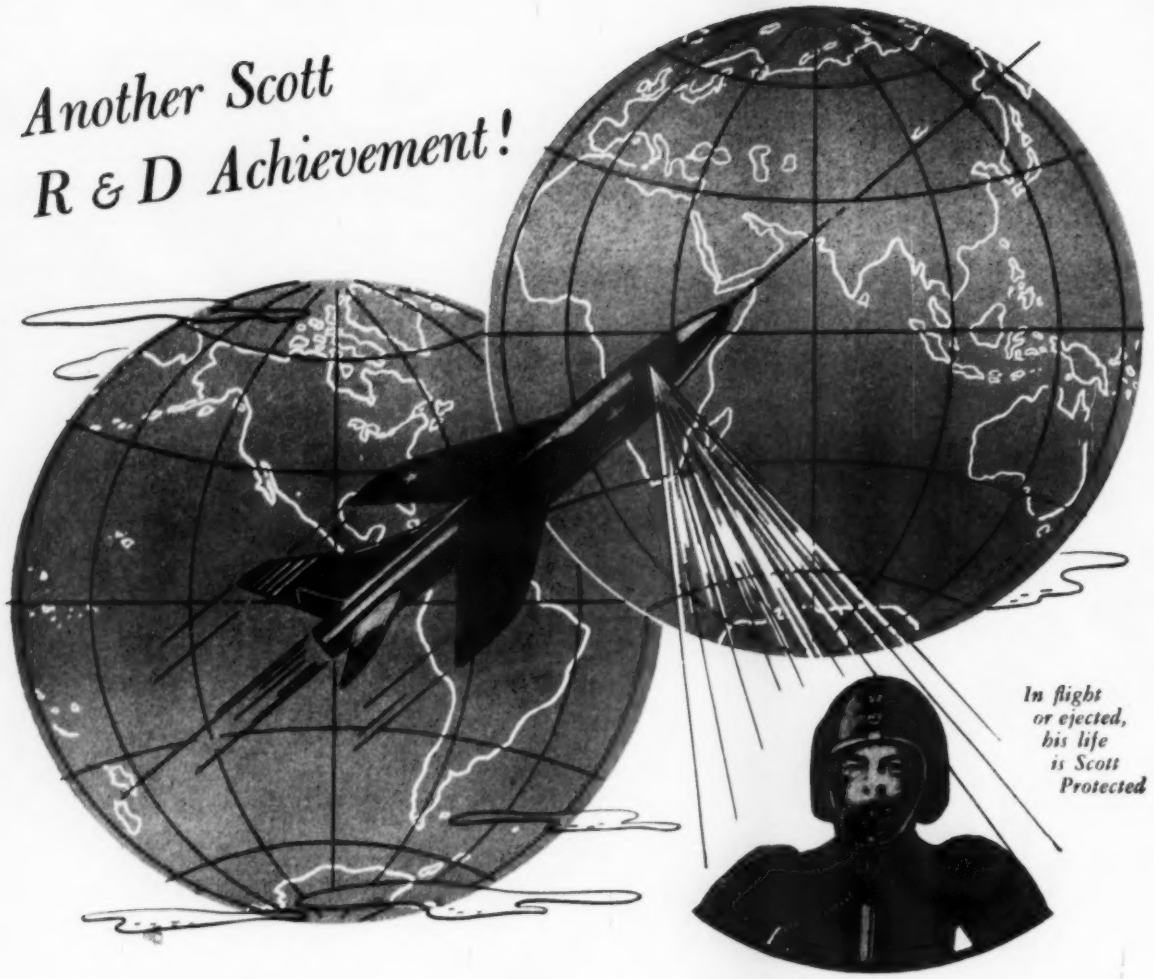
AC Fine Wire Electrodes have platinum tips to provide smoother idling and high heat conduction—to prevent pre-ignition and ice-bridging. They're less susceptible to lead fouling.

AC Aircraft Spark Plugs have been proved in millions of hours of flight in military and airline planes. You'll find them best for the planes you fly!

AC SPARK PLUG ✣ THE ELECTRONICS DIVISION OF GENERAL MOTORS

DISTRIBUTED BY: Airwork Corporation: Millville, New Jersey; Miami Springs, Florida; Newark, New Jersey; Atlanta, Georgia; Alexandria, Virginia; Cleveland, Ohio. **Pacific Airmotive Corporation:** Burbank, California; Seattle, Washington; Oakland, California; Kansas City, Kansas; Denver, Colorado; Linden, New Jersey. **Southwest Airmotive Company:** Dallas, Texas; Kansas City, Kansas; Denver, Colorado. **Standard Aero Engine Ltd.:** Winnipeg, Manitoba; Vancouver, B.C.; Edmonton, Alberta **Van Dusen Aircraft Supplies, Inc.:** Chicago, Illinois; Minneapolis, Minnesota; Teterboro, New Jersey; East Boston, Massachusetts; Alexandria, Virginia.

Another Scott R & D Achievement!



In flight or ejected, his life is Scott Protected

A Completely Integrated System of High Altitude Breathing & Survival Protection

For a quarter of a century the practical results of Scott Research and Development have enabled Scott Aviation to maintain its leadership in aviation breathing equipment. Now Scott announces production of a completely integrated system of high altitude breathing and survival protection, so necessary for the pilot in today's high performance, supersonic military jet aircraft.

Whether in flight or ejected, breathing protection is automatically maintained. In an emergency, aircraft main supply lines are disconnected automatically and the self-contained unit is actuated without human effort. Simplification is the keynote of this new Scott System. The usual maze of hoses and wires has been eliminated . . . with considerable weight saving.

For the shape of things to come, keep an eye on Scott R & D!

NOW READY FOR PRODUCTION

Scott has ever been cognizant of the importance of Applied Human Engineering. This new high altitude survival protection system is an example. It is past the experimental stage and is ready for production. Further information available to persons active in this field. Write for it today!

SINCE 1932 Scott

SCOTT AVIATION CORP.

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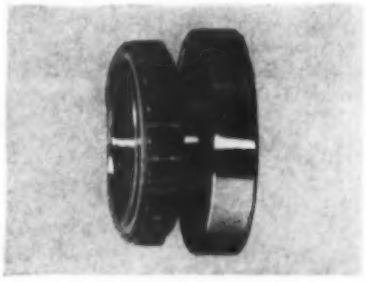
Export: Southern Oxygen Co., 15 West 57th Street, New York 19, N.Y.

Margin for Error . . . *None!*

You swing into your final approach. At precisely the right instant the Landing Signal Officer flags you to cut your power—and you're aboard! ☆ Such skill and precision is indicative of that which is required today in *every* phase of the aircraft industry. The bearings in modern jet turbines, for instance, must be held to accurate tolerances measured in millionths of an inch. That's why the leading jet turbine manufacturers specify Bower aircraft bearings first. Their exceptional high quality and unerring precision allow Bower bearings to stand unbelievable turbine speeds and temperatures—that match the supersonic speeds of today's jet aircraft—*with a minimum of lubrication.* ☆ Whatever *you* produce, if it uses bearings, specify Bower! Choose from a complete line of tapered, straight and journal roller bearings for every field of transportation and industry.

BOWER ROLLER BEARING DIVISION
FEDERAL-MOGUL-BOWER BEARINGS, INC. • DETROIT 14, MICHIGAN



IDEALLY SUITED TO HIGH-SPEED OPERATION

Built to hold their precision indefinitely, these aircraft bearings are recommended wherever superior quality and high-speed operation are required. For some applications, a special alloy steel—developed jointly by Bower and several aircraft companies—is used.

BOWER

ROLLER BEARINGS

PISTON OR TURBINE

...Dependable Aircraft Power

Look ahead ...join the air force

Continental Motors and its CAE subsidiary are successfully meeting a wide variety of aircraft power requirements. Dependable Continental engines of piston or turbine type now power not only leading makes of fixed wing utility and trainer aircraft, but modern high-performance helicopters as well. Engine-building experience dating from 1902 clinches the "rightness" of the engine with the Continental name.

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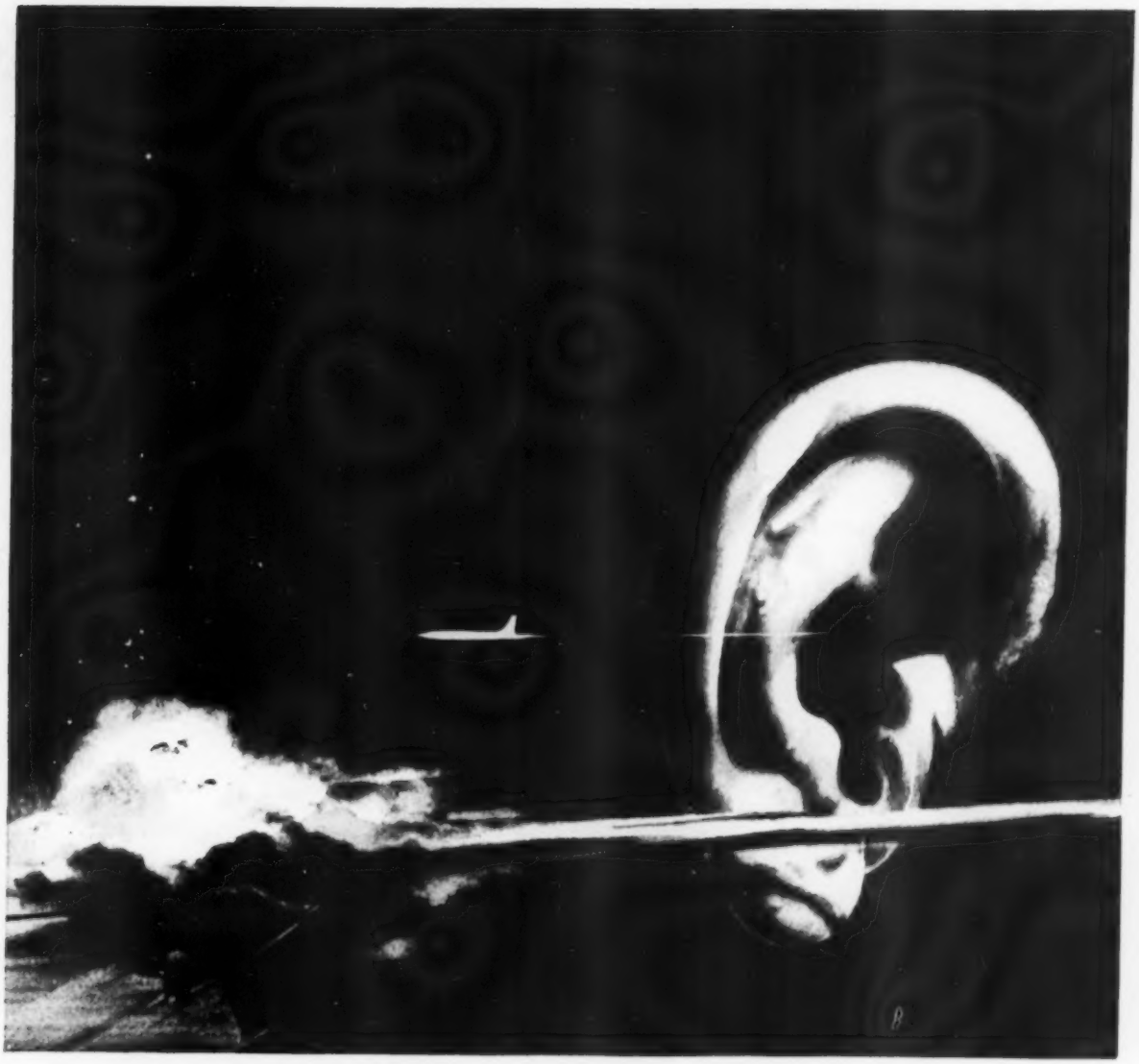

THE **SOUND** OF PROGRESS

What is the sound of Progress? It's the whine of a jet... the busy hum of a computer... the deep roar of a rocket engine... the swish of helicopter blades. But the most important "sound" of all is mute... that of creative minds at work, solving tomorrow's problems today.

These sounds... accomplishments of engineering research... represent many "firsts" at Bell Aircraft. Here the sound of genius is reflected in such advanced projects as the GAM-63 Rascal, a long range strategic air-to-surface guided missile... the bold quest of the X-2, the world's fastest and highest flying airplane... the jet-powered X-14 VTOL... the XV-3 convertiplane... the XH-40 turbine-powered helicopter... rocket engines... electronics... servomechanisms... and atomic research.

Bell's engineers are daily meeting and resolving tomorrow's complex problems in all fields of science. ***These are the sounds of progress.***

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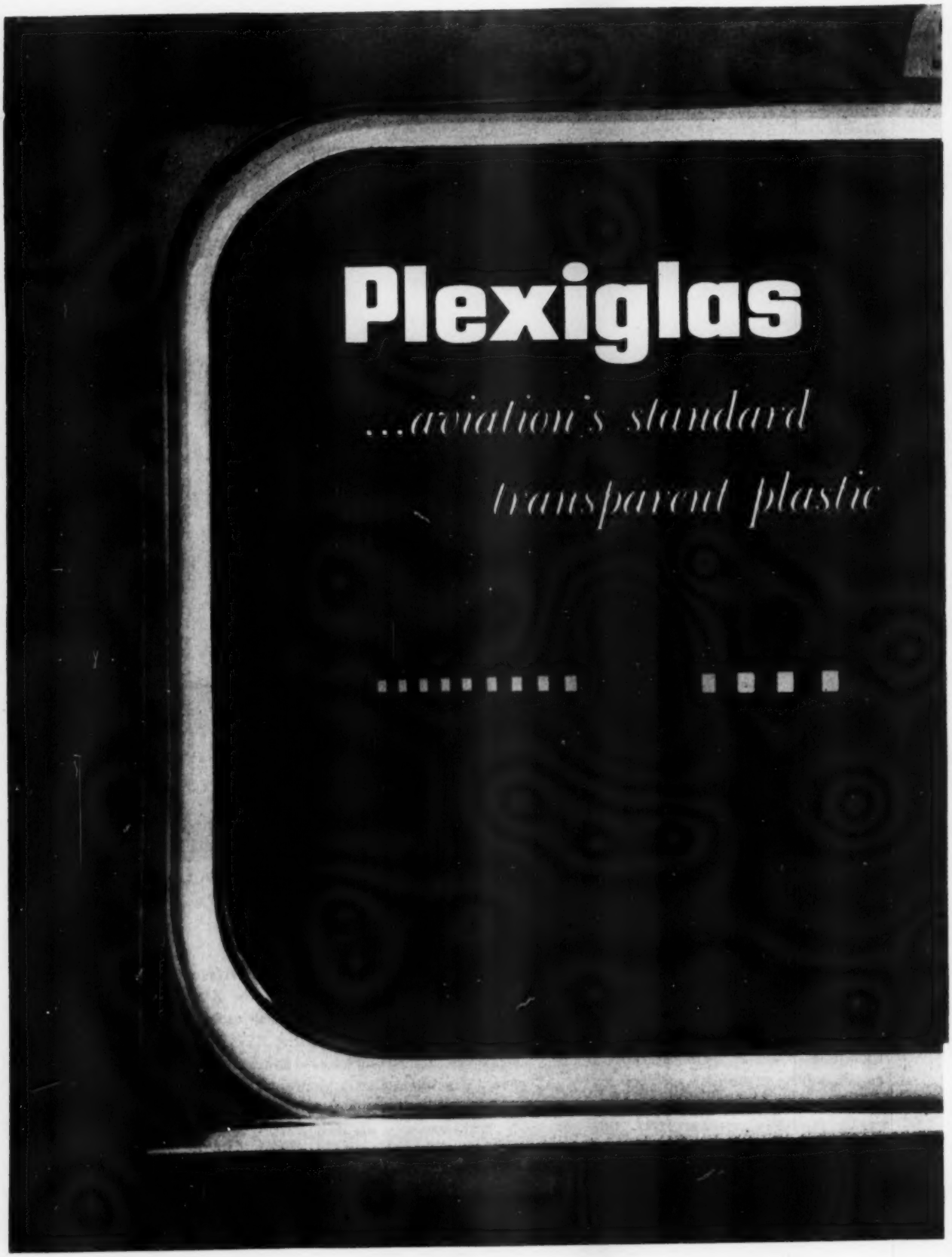
RESEARCH, DEVELOPMENT AND PRODUCTION IN THE FIELDS OF: Guided Missiles • Research Aircraft Servomechanisms • Electronics • Rocket Engines • Electronic Control Systems • Vertical Rising Aircraft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...aviation's standard
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Representatives in principal foreign countries
PLEXIGLAS is a trademark, Reg. U.S. Pat. Off. and in other principal countries in the Western Hemisphere.
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"This refers to yours of the 10th..."

Some people still hammer out communications one character at a time.

Others use DATAFAX—the fast Stewart-Warner electronic way to transmit all data over standard telephone lines.

Datafax transmits and records any material: correspondence, weather maps, pictures, any printed matter, even handwritten notes. And since copies are exact duplicate images of the original, chance for error is completely eliminated.

Cost?

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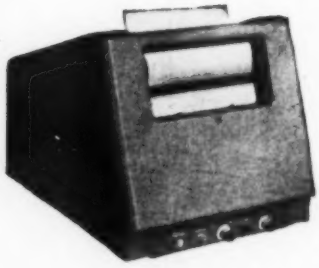
Chances are your operations...reservations...maintenance and accounting procedures have outgrown Stone Age Communications. If so, you'll want to find out about Datafax. First, send for your copy of the free Datafax bulletin. Write: Stewart-Warner Electronics, Dept. 14, 1300 No. Kostner Ave., Chicago 51, Illinois.

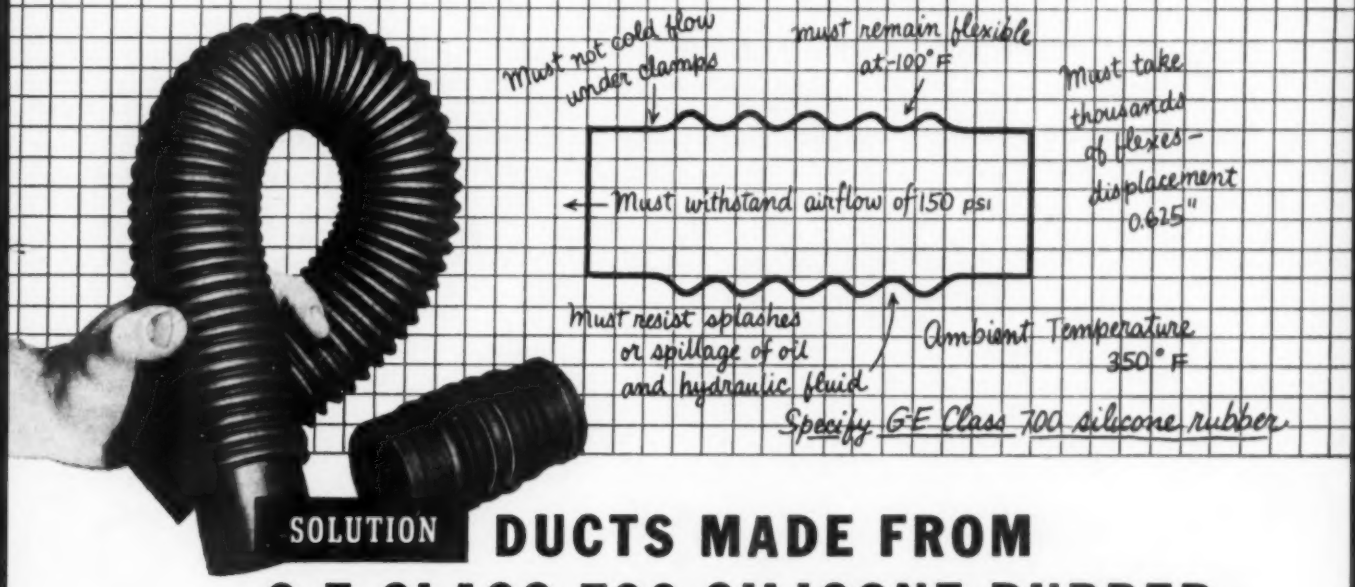


STEWART WARNER **SW ELECTRONICS**

a Division of Stewart-Warner Corporation

SOLVING DESIGN PROBLEMS WITH GENERAL ELECTRIC SILICONE RUBBER

PROBLEM Find material for flexible heater ducting


Must not cold flow under clamps
must remain flexible at -100° F
Must take thousands of flexes — displacement 0.625"
Must withstand airflow of 150 psi
Must resist splashes or spillage of oil and hydraulic fluid
Ambient Temperature 350° F
Specify G-E Class 700 silicone rubber

SOLUTION

DUCTS MADE FROM G-E CLASS 700 SILICONE RUBBER—

RESISTS 600°F, FLAMES AND FUELS

Problems like this in aircraft de-icing, engine-warming and cabin-heating ducts are being successfully solved with General Electric's improved Class 700 silicone rubber. With a service range from −120° to 600°F, ducts made of G-E Class 700 resist prolonged heat at 600°F, can carry hot air up to 700°F. Tests prove good resistance to common aircraft fuels and lubricants, including MIL-L-7808. Ducts made from Class 700 G-E silicone rubber exhibit low compression set—will not "cold flow" under clamps. And with improved flame resistance, an important safety feature, Class 700 is proving to be the ideal material for all flexible hot-air ducting applications.

High temperature ducting is only one application of Class 700 G-E silicone rubber. It may also be molded, extruded or calendared on cloth to form seals and gaskets for a wide variety of applications.

Where can YOU use G-E silicone rubber?

There's a kind of G-E silicone rubber for almost every requirement, classified according to dominant property for easy selection and specification. For example: Class 300 offers the best recovery after compression *of any known rubber!* Class 500 provides flexibility *at 150°F below zero!* Which class is best for *you?*

For more details on G-E silicone rubber, see your "Sweet's Product Design File" or MAIL COUPON TODAY!

SILICONE RUBBER
Outstanding resistance to extreme temperatures
Superior resistance to compression set
Electrical properties stable at high temperatures
Unequalled resistance to ages, ozone, weathering

Progress Is Our Most Important Product

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SILICONE PRODUCTS DEPARTMENT
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(Specify area of application.)

Name _____

Position _____

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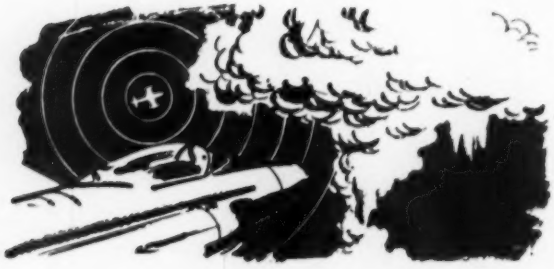
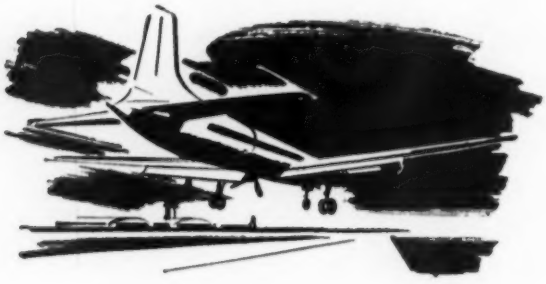
IN CANADA: Mail to Canadian General Electric Company, Ltd., Toronto

In these fields Sperry capability serves the military and the aviation industry:

With *proven capability* its constant goal, Sperry has created specialized groups to design, develop and produce a wide range of products for aviation. Through bringing together, in integrated divisions or departments, talented staffs of top specialists in their fields, customers are served more efficiently and more economically. Whether your organization is military or civil, whether your needs are systems, equipment or components, you can be sure of specialized attention from the Sperry group best qualified to serve you.





FLIGHT INSTRUMENTS AND CONTROLS

Flight Control Systems
Integrated Instrument Systems
Gyrosyn* Compass Systems
Flight Instruments
Automatic Approach Controls
Radio Beam Couplers
Engine Control Systems
Engine Analyzers
Drone Controls
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Helicopter Instruments

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Air-to-surface
Surface-to-air
Surface-to-surface
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Fire Control
Radar Beacons
Navigation
Tactical
Long Range Search
Air Defense
Ship Defense

Flight Instruments and Controls

Missiles–Radars

Special Systems

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Antennas, Lenses, and Scanner Systems
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ELECTRON DEVICES

Multiplier Klystrons
Microwave Relay Transmitter Amplifiers
Medium-Power Metal Traveling Wave Tubes
High-Power Radar-Driven Amplifiers
Microwave Relay Transmitter Oscillators
Radar Local Oscillators
High-Power Radar Transmitter Amplifiers
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Janitrol purge gas generators provide safe armorplate of gas for fuels in modern aircraft.

Janitrol Platular* heat exchangers in modular units, reduce weight and increase design freedom.

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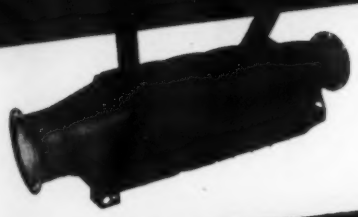
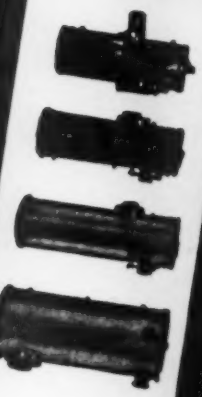


what's new in the Janitrol line

Janitrol standard couplings for compressor air ductwork save up to 40% in weight.

Janitrol hot fuel prime units help engines start in seconds and run free in minutes, from −65°F.

Janitrol pneumatic control valves for critical high pressure applications combine functions, save weight and space.

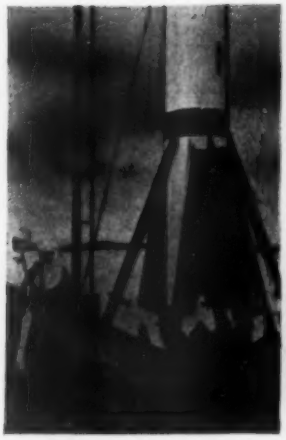


Janitrol combustion heaters continue to provide the last word in versatility, easy installation, and dependability.

Janitrol

DISTRICT ENGINEERING OFFICES: WASHINGTON, D.C., PHILADELPHIA, COLUMBUS, FT. WORTH, HOLLYWOOD

Fluoroflex-T TEFLON® hose solves these problems



HANDLING HIGHLY CORROSIVE FLUIDS

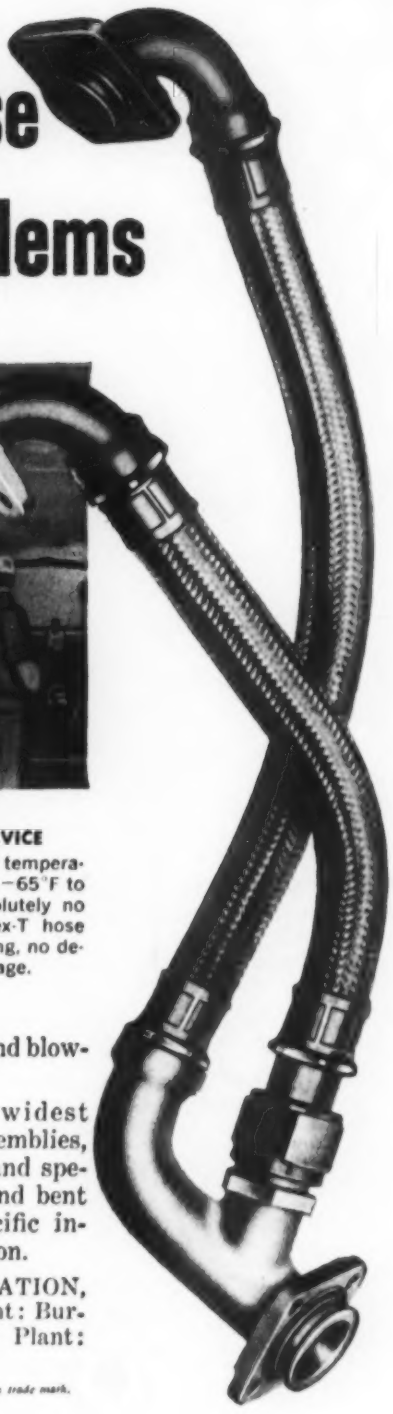
In flexible lines, nothing surpasses a compact, inert Fluoroflex-T assembly for conveying corrosive propellants, nitric acid, MIL-L-7808 oil, and JP-4 fuel.

PERFORMANCE IN VITAL CONTROL JOBS

Fluoroflex-T lightweight assemblies resist "ballooning" under pressure and elevated temperatures . . . assuring instant response in braking and other control systems.

HIGH OR LOW TEMPERATURE SERVICE

Fluids and gases at temperatures ranging from −65°F to +450°F have absolutely no affect on Fluoroflex-T hose assemblies. No aging, no deterioration, no leakage.



FLUOROFLEX®-T hose is the *original* Teflon hose, now proved by *four years flight experience.* With *patented* tube, it assures you high integrity, genuine aircraft quality assemblies. Permanently swaged fittings are both leakproof and blow-off-proof.

Resistoflex offers the widest range of Teflon hose assemblies, preformed configurations, and special combinations of hose and bent tubes. Contact us for specific information on your application.

RESISTOFLEX CORPORATION, Roseland, N.J.; Western Plant: Burbank, Calif.; Southwestern Plant: Dallas, Tex.

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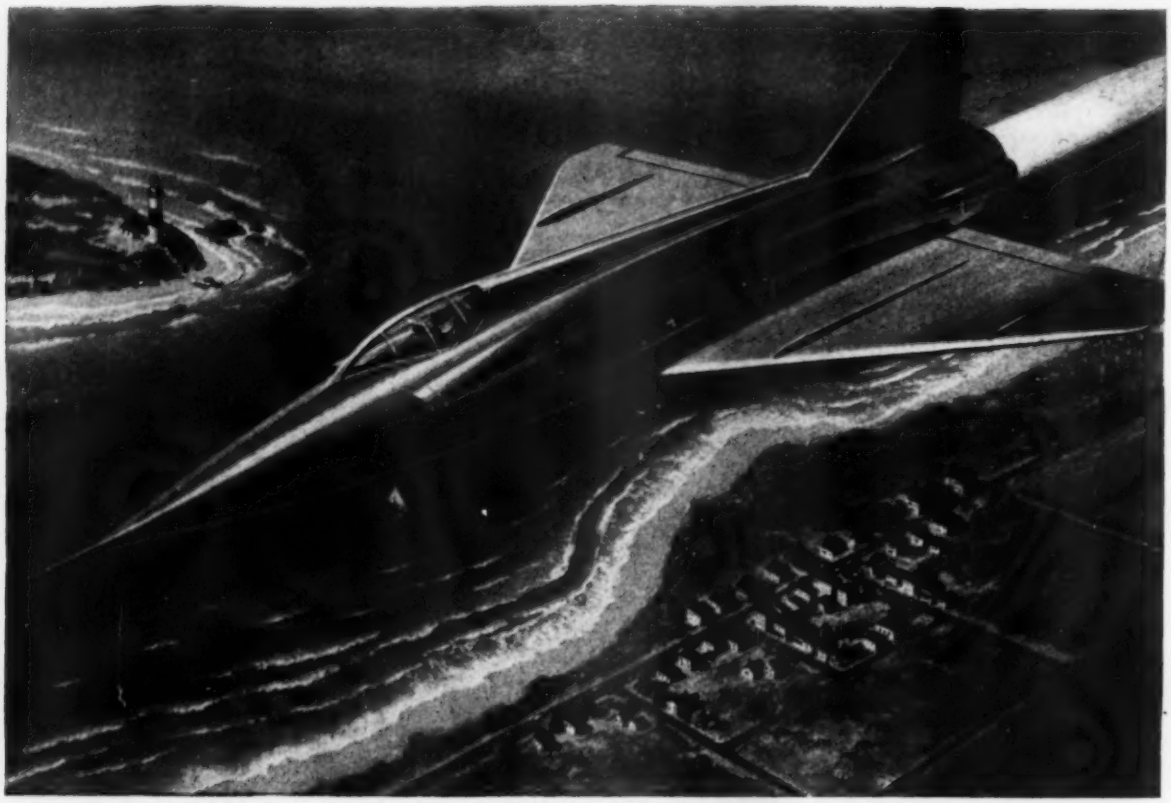
20th year of service to industry

Resistoflex



One source for all your aircraft tubing needs

SUPERIOR OFFERS WIDE VARIETY OF SPECIAL-PURPOSE TUBING IN MANY DIFFERENT SIZES AND ALLOYS

Many aircraft manufacturers have discovered that Superior produces as standard what many other firms classify as specialty tubing. You can get hydraulic tubing, large OD light-wall tubing, all types of instrument tubing, including capillary, mechanical tubing produced from super alloys for high temperature service, structural tubing from alloy steels, and our newest—titanium tubing. Superior tubing meets these requirements: light weight; close tolerance; workability; ability to withstand vibration, shock, high temperature, high pressure surges.

Providing the correct conduit materials for mechanical remote controls is a good example of Superior's ability to supply a variety of analyses for specific needs. Because of the varied conditions of service encountered, Teleflex Incorporated, of North Wales, Pa., manufacturer of mechanical remote controls, subjects its products to exhaustive tests for strength at high temperatures and corrosion resistance. This concern also requires close tolerances for the tubing bore to assure perfect fit of the cable and ability of the tubing to be flared without cracking.

Superior tubing meets all the Teleflex requirements for temperature service, wear resistance, tolerances and strength, and we supply a wide range, in production quantities, of stainless, carbon and nonferrous tubing from our over 63 standard analyses.

If you have a problem involving high-quality aircraft tubing, let Superior solve it for you. Write Superior Tube Company, 2040 Germantown Ave., Norristown, Pa.

The impact test at the Teleflex laboratory measures the force the conduit will withstand before it crushes and interferes with the cable.

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Send for your free copies of "A Guide to the Selection and Application of Superior Tubing." Contains technical and application data on standard alloys.

Superior Tube

The big name in small tubing

NORRISTOWN, PA.

All analyses .010" to ¾" OD—certain analyses in light walls up to 2½" OD

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Who Says...
AIRPLANES DON'T BACK UP?

THEY ALL DO WHEN VIEWED FROM A *Super Ventura*

HOW WOULD YOU LIKE . . .

- *To loaf along at 300 MPH at 8,000 feet altitude?*
- *To operate from moderate size airports with airline safety?*
- *To fly over 2,000 miles non-stop with a comfortable fuel reserve?*
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- *To have the satisfaction of riding behind the most thoroughly proven and dependable engines in the industry?*

You will agree that these are highly desirable features, but you will be amazed after becoming acquainted with the SUPER VENTURA to find that these are only a few of its outstanding qualities. Only by flying the SUPER VENTURA and comparing it, feature by feature, with all other aircraft can you begin to fully realize that it is the world's [illegible]tanding executive airplane. Write or call today.

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The Super Ventura is leading all other executive aircraft of its type in sales

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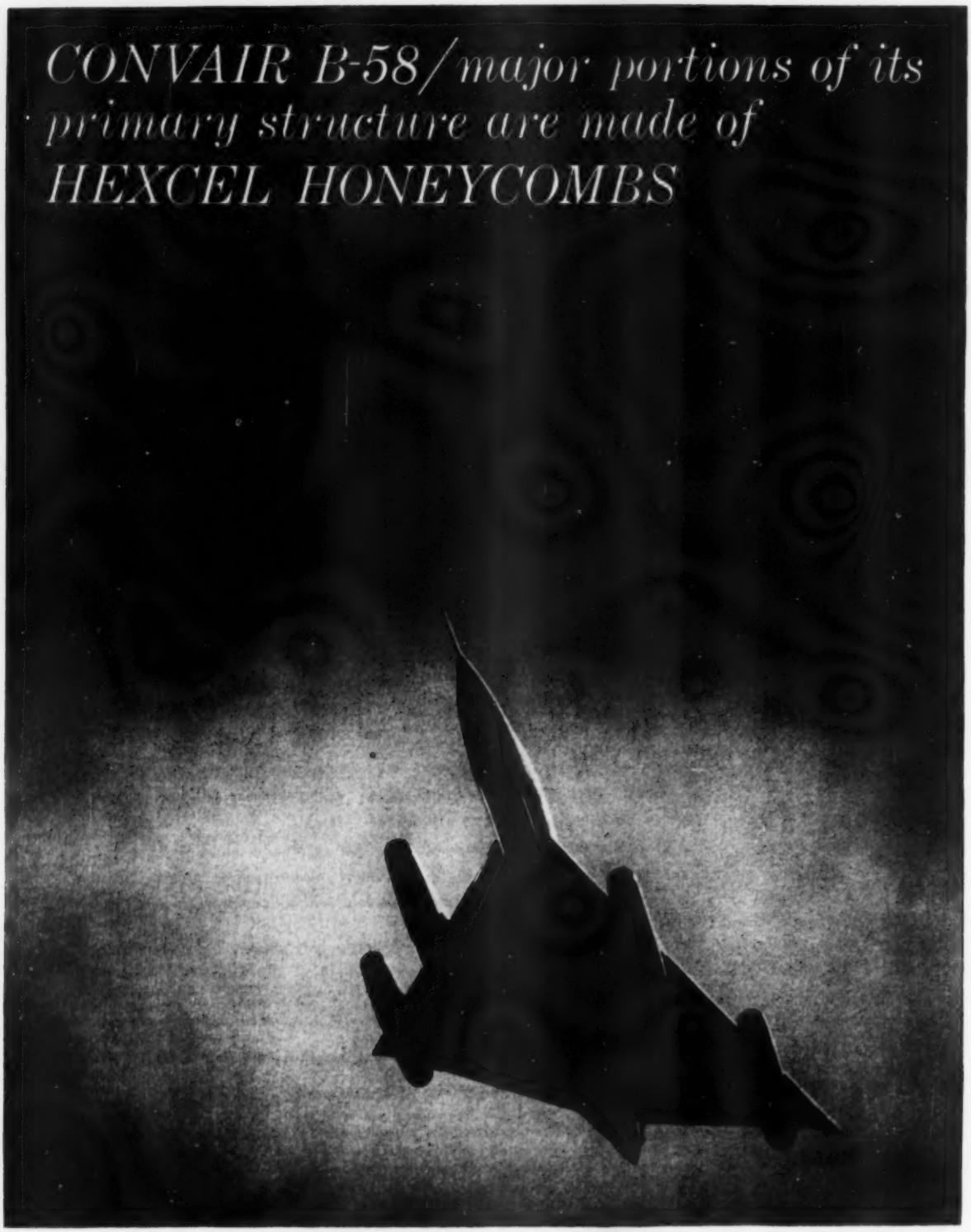
CONVAIR B-58/major portions of its primary structure are made of HEXCEL HONEYCOMBS



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America's leading producer of honeycomb core materials

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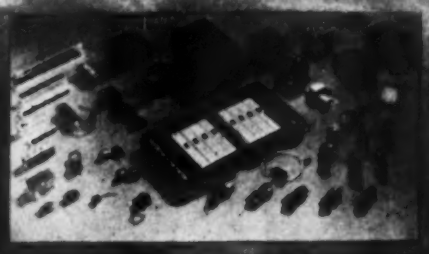
BENDIX-PACIFIC

HEADQUARTERS FOR FLIGHT TEST INSTRUMENTATION



✓ MORE TELEMETERING EQUIPMENT FROM BENDIX-PACIFIC

Whatever type of aircraft is to be flight tested, Bendix-Pacific can supply the exact telemetering component for every required measurement. From this one source the widest selection of airborne components is available, including transmitters, oscillators, signal conversion units, power supplies and also complete receiving station facilities.

✓ MORE TELEMETERING EXPERIENCE AT BENDIX-PACIFIC

For more than 10 years Bendix-Pacific has been designing and producing telemetering components and systems. Bendix-Pacific equipment pioneered in early flight test instrumentation and has become an indispensable part of many major airframe companies' flight test programs.

✓ BETTER RESULTS WITH BENDIX-PACIFIC TELEMETERING

The time-tested reliability of Bendix-Pacific telemetering equipment assures you of accurate, dependable instrumentation. Bendix-Pacific has earned its leadership through years of experience in providing the right equipment for aircraft flight instrumentation as well as for missile and pilotless aircraft use.

Write for complete equipment specifications. A qualified engineer will gladly call at your convenience to fully explain Bendix-Pacific instrumentation equipment.

Bendix
PACIFIC DIVISION
Bendix Aviation Corporation
NORTH HOLLYWOOD, CALIF.

design with **austenal** in mind...

Austenal **microcast** *gives you better turbine power wheels more economically, faster*

In many sizes, for most turbine applications Austenal Microcast gives you better, less expensive power wheels.

Here's why. Austenal makes turbine wheels by investment casting, thus eliminating costly machining and at the same time allowing the use of new high-strength, ultra-high-temperature alloys that are impractical to machine.

Too, investment casting is dimensionally accurate. Tolerances are held to within ±.005" per inch, and blades can be of virtually any thinness (down to .020") contingent, of course, upon wheel design and size.

Austenal manufactures wheels in many sizes from two-inch midgets to giants 17 inches in diameter. These units are made to the most exacting standards, rigorously checked and re-checked during every production phase to guarantee they are exact – internally sound and externally perfect.

...It's **NEW** *from Austenal*

"Design with Microcast in Mind," Austenal's latest informative booklet, tells you how to get the greatest benefit from investment casting. *Write for it today.*

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Teamwork

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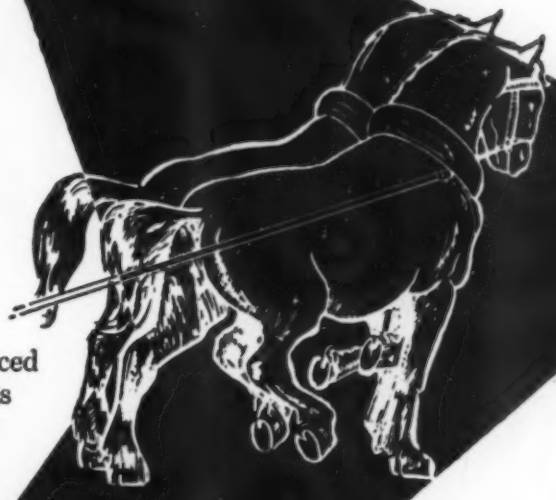

Progress is the result of advanced design and advanced materials keeping abreast of each other . . . meeting, *as a team*, the enormous responsibilities imposed by the aircraft industry.

Write for brochures detailing application and performance characteristics of METLBOND 302 and CONOLON 506 laminating materials.

A STRIKING EXAMPLE OF NARMCO'S LEADERSHIP IN DYNAMIC MATERIALS DEVELOPMENT:

This sandwich-type, static test article was designed and fabricated by Narmco, Inc. for the Air Force and proved its structural efficiency by achieving a weight saving in excess of 50% over its metal counterpart. Carried externally to the aircraft, the component was developed to accommodate the same basic load as a similar aluminum structure. It employed Conolon laminating materials, Metlbond 302, and aluminum honeycomb core. It successfully met all elevated temperature static tests, thus substantiating predicted results.

NARMCO

Narmco technical field representatives throughout the United States and Canada can assist in solving your structural design problems quickly, efficiently, and economically. For immediate assistance write, wire, or phone.

Narmco Resins & Coatings Company, Dept. 12, 600 Victoria Street, Costa Mesa, Calif.

Cessna T-37 designed for Jet Training

To meet jet age demands, the U. S. Air Force requires a jet trainer that makes it easy for cadet-pilots to master first-line combat airplanes.

The Cessna-developed T-37 introduces the cadet to all combat jet airplane characteristics while training on this safe, easy-to-fly jet trainer.

It is designed to provide the Air Force with a jet trainer that can be operated at substantial savings and cover the most important and longest phase of the cadet-pilot's jet training.

It is a privilege for us here at Cessna to team with the Air Force in its forward-thinking plans for the jet age. CESSNA AIRCRAFT COMPANY, Wichita, Kans.

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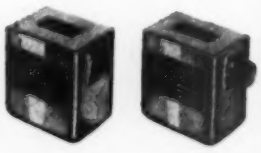

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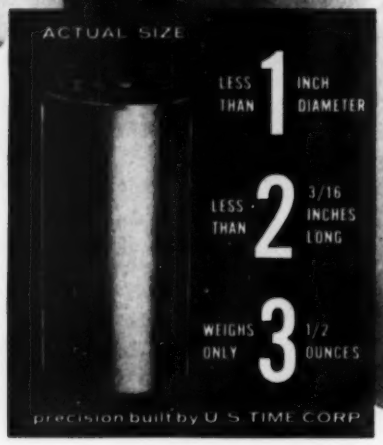

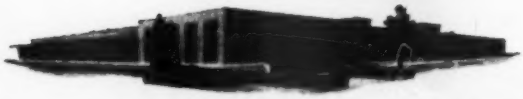

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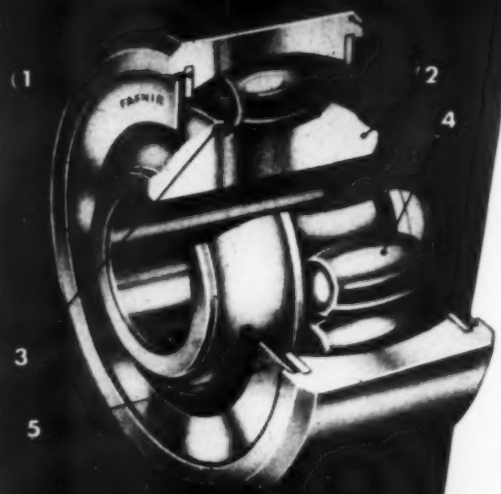

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DSRP4	.2500	.9014	.625	.464	.404	.005	.032	12	.1514	3025	.06
DSRP5	.3125	1.2500	.812	.656	.515	.015	.032	11	.2303	7350	.16
DSRP6	.3750	1.4375	.937	.750	.564	.015	.032	11	.2681	9480	.24
DSRP8	.5000	1.6875	1.000	.812	.775	.015	.044	12	.3033	12500	.36
DSRP10	.6250	1.9375	1.125	.937	.869	.015	.044	14	.3016	17700	.55
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AVIATION WEEK

Volume 66
No. 8
February 25, 1957

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Aviation Outlook Bright for 1957

Aviation will do an $11 billion business in 1957, grossing the largest revenues in its post-war history.

This $11 billion gross will be split as follows:

- ***$6.7 billion for military aircraft, engines and related equipment.***
- ***$2 billion for guided missiles and related equipment.***
- ***$1 billion for military and civil ground based avionic equipment.***
- ***$1.3 billion in airline revenues.***

In addition, the industry will get about a half billion in military research and development work and about $100 million for new plant facilities. The aircraft manufacturing industry entered 1957 with a $21 billion backlog of which about $18 billion represented military aircraft and missiles and $3 billion airline transport and business flying planes.

Of the total $11 billion gross revenues outlined above, the avionics segment of the industry will account for over $3 billion. In addition to the billion dollars earmarked for military and civil ground based avionic equipment, the missile program will absorb almost another billion dollars with just under two billion in aircraft and engine expenditures devoted to avionic equipment. Airline equipment buying also will include multi-million dollar expenditures for airborne avionic equipment.

OUTLOOK FOR NEW BUSINESS

IN ADDITION TO THIS sales outlook for 1957, which in the manufacturing field is a reflection of military budget expenditures, the outlook for new business also looks good. New military business is a reflection of the new procurement obligational authority requested for Fiscal 1958 in the Defense Department budget. As the budget request now stands before Congress, it calls for about $9.5 billion in new aviation procurement. This breaks down into approximately $6.2 billion aircraft and engines; $2.6 billion for missiles; $600 million for ground-based avionic equipment and $300 million for new production facilities, and about $800 million for research and development. There is sure to be spirited congressional debate over the adequacy of these procurement levels, and any major change in the Fiscal 1958 airpower budget would be aimed at increasing it substantially.

While industry's gross sales are apt to reach a post-war peak in 1957, manufacturers' profits are due for a dip from the 1955-56 level because of the heavy expenditures being poured out of earnings into research and development facilities and programs. The aircraft manufacturing industry clearly recognizes that its future depends on pushing at a maximum rate along the whole perimeter of its rapidly expanding frontier. Consequently, it is taking a larger share of its earnings than ever before to invest in this technical future.

NEW PROFIT PATTERN

THE OTHER MAJOR FACTOR that combines with the swift pace of technological development to etch a new profit pattern for 1957 is the steadily increasing competition among individual firms for the military airpower sales dollar. This trend toward more selective buying by USAF, Navy and Army on their aircraft, engine, avionics and missile hardware began about a year after the end of the Korean war, but its full effects are just beginning to be felt by the industry. While total military airpower expenditures are at a slightly rising level, larger portions of the total are being invested in specific weapon systems such as the Boeing B-52 bomber and KC-135 tanker programs, the Convair F-102 and F-106 interceptor programs and the Martin and Convair intercontinental ballistic missile systems, leaving much smaller portions of the total to invest in a wide variety of minor weapon systems.

With the emphasis on this trend, combined with the dependence upon major new scientific breakthroughs that offer large performance improvement and the weapon system concept of development and production, it appears inevitable that a trend will become clearly visible during 1957 in which the larger industrial complexes in this business will grow larger. What are now

the smaller prime contractors will either turn into segments of the larger complexes or create new giant competitors through mergers.

GREATER COMPETITION

COMPETITION BETWEEN prime weapon system contractors and among major sub-system developers will become fiercer than ever during 1957. This is because the reward for success is now much greater and the penalties for failure more drastic. There will be wider variations in the fortunes of individual firms than ever before during 1957 and 1958. Some will reach new peaks in sales and profits, but others face a bleak financial outlook.

Airframe weight deliveries—the best index of military business—will continue at about the 1956 level as larger volumes of missile deliveries will compensate for fewer aircraft deliveries. Manufacturers in the commercial field will be working primarily to reduce their $500 million backlog of piston-engine transport orders during 1957 before beginning to make inroads on their $2 billion backlog of turbine transports.

Business and utility plane manufacturers can expect another good year in 1957 with sales jumping to a record $1.10 million total. Introduction of new models will sharpen competition to its highest pitch in recent years, although the full effect of these new aircraft will not be felt until 1958. A sharp rise in the production rate experienced in 1956 when 7,500 civil planes were delivered will not continue into 1957.

MORE MONEY FOR AVIONICS

AVIONICS MANUFACTURERS will attract an increasing share of the dollars spent in both military and civil aviation. In the military picture, the emergence of missiles as a supplement to piloted aircraft portends a rising tide of avionics expenditures. The trend of recent years toward increasing complexity and semi-automatic operation of piloted aircraft have brought the percentage of avionics involved to about 35% of flyaway cost for a modern military aircraft. In missiles, this percentage increased to about 50%. With the increased role of avionics in military airpower has come increased pressure on manufacturers and designers for greater reliability and microminiaturization to meet the requirements of hypersonic long range missiles.

Combination of military and civil air traffic control and air defense systems will place a heavy demand upon the avionics manufacturers for both airborne and ground equipment. Resolution of the Vortac controversy in 1956 opened the road for major 1957 improvements in civil-military navigation and air traffic control systems.

Increasing missile production in which airframe, avionics and propulsion manufacturers are combining to develop and produce a wide variety of new weapons will emerge during 1957 into a significant segment of the military airpower picture. Production is still concentrated on relatively simple air-to-air missiles, short-range subsonic tactical missiles and relatively unsophisticated air-to-ground missiles with major development efforts now placed on the hypersonic ballistic missiles capable of operating over ranges of from 1,500 to 5,000 miles. Missile development and production utilizes much the same basic technology as employed in supersonic aircraft development, but there are indications that new types of production facilities are required for volume production of ballistic missiles.

NEW AIRLINE GROWTH

AIRLINES WILL GROSS revenues between $7.8 and $8 billion in 1957 as they increase their share of the total travel market. During 1956, the airlines for the second consecutive year gained more passenger volume than the surface carriers lost, indicating that air travel is creating a basically new travel market. Traffic control bottlenecks and equipment shortages will be a limiting factor on the airlines' growth rate during 1957, but this rate should be close to the 17.4% gain in 1956 in total revenue ton-miles for the entire air transport industry, including domestic trunklines, international carriers, helicopter services and Alaskan airlines. These carriers totalled 3,570,904,000 revenue ton-miles for 1956 as compared with 3,042,390,000 in 1955. Passenger revenues gained 12.7% in 1956, and a continued rise is expected for 1957 even without the 6% fare increase the airlines are seeking. Total of 47 million passengers were carried in 1956, a gain of nearly 13% over 1955.

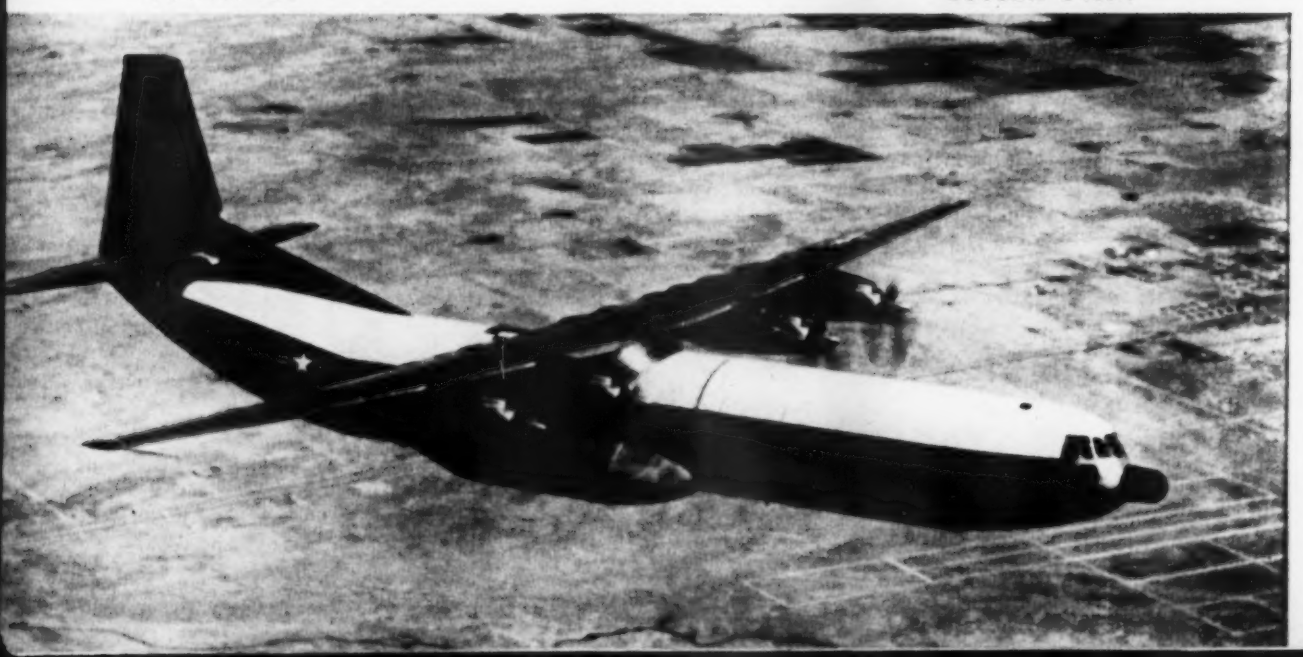
While the outlook for 1957 is for general stability in the industry, with the major effort on producing types of hardware already familiar in the military arsenal and in airline service, both the manufacturing industry and the airlines are in the midst of major ferment in preparing for new phases of the technological revolution that has dominated the industry almost from the moment of its birth 53 years ago. The airlines are planning and preparing for their jump into the jet transport era while the military are pushing hard toward the hypersonic intercontinental ballistic missile.

—ROBERT HOTZ

BOEING B-52 STRATOFORTRESS and KC-135 JET STRATOTANKER

CONVAIR B-58

DOUGLAS C-133A



LOCKHEED F-104 STARFIGHTER

AVIATION WEEK COLOR PORTFOLIO

24th ANNUAL INVENTORY OF AIRPOWER

NORTH AMERICAN F-100 SUPER SABERS

▲ MARTIN B-57E WITH TOW TARGET

▼ LOCKHEED C-130A HERCULES

CHANCE VOUGHT F8U-1 CRUSADER

GRUMMAN F9F-8 COUGAR

▼ MARTIN XP6M-1 SEAMASTER

GRUMMAN F11F-1F TIGER

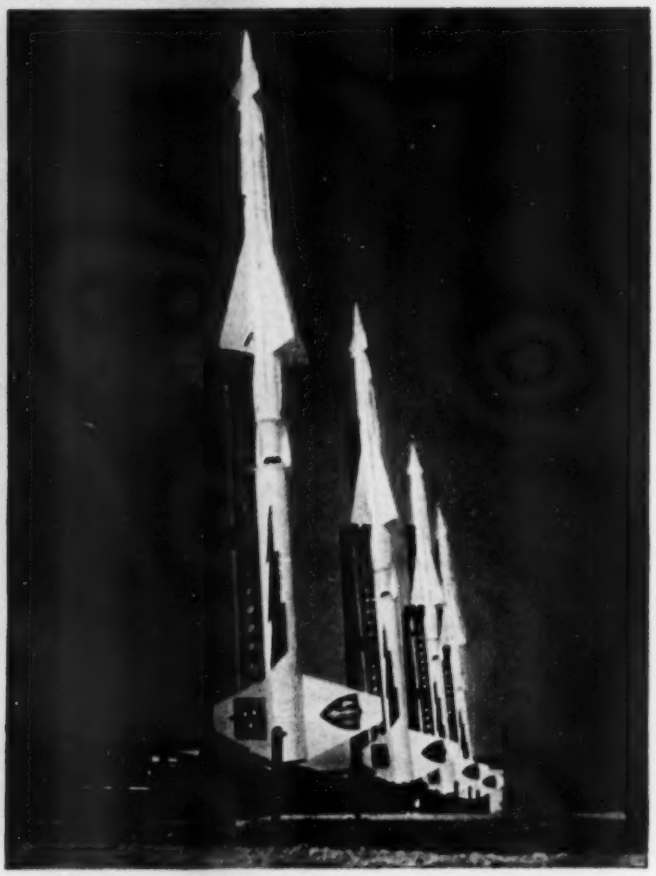
▼ DOUGLAS F4D-1 SKYRAYS

▼ BELL XH-40

▼ SIKORSKY HR2S-1W

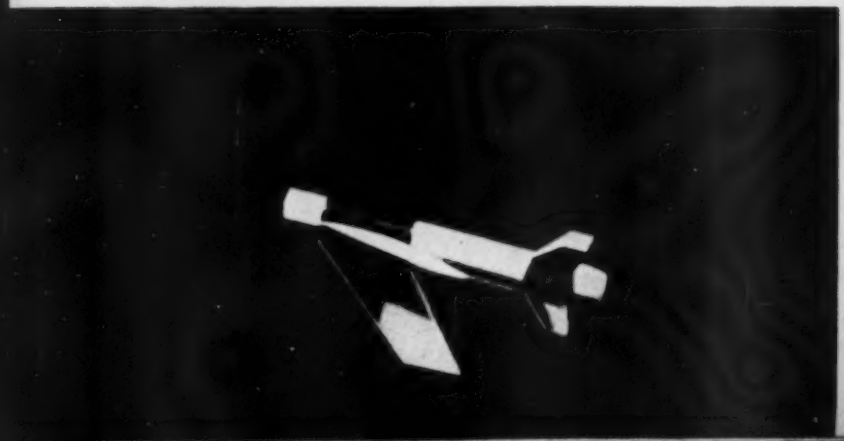
McDONNELL F3H-2N DEMON WITH SPARROW MISSILES

▲ REDSTONE



▼ LACROSSE

▲ NIKE



▼ BOMBER DEFENSE MISSILE (BDM)

TEMCO TT-1

PIPER PA-24 COMANCHE

BEECH 95 TRAVEL AIR

TRECKER ROYAL GULL

CESSNA 620

PRACTICE MAKES PERFECT— In 1957, as in 1776, one measure of effective defense is the true aim and steady skill of a nation's fighting men. To make American warriors proficient against complex modern weapons, Northrop Aircraft's subsidiary, Radioplane Company, produces targets like the rocket-powered RP-70 type, a light, low-cost drone, which simulates a high speed modern jet plane or missile at stratospheric altitudes. Like Northrop's new supersonic Air Force trainer airplane and Snark SM-62 intercontinental guided missile, the RP-70 is another example of the Northrop-Radioplane policy of "*security with solvency*" which applies advanced science and technology to deliver the maximum in national defense for the minimum in tax dollars.

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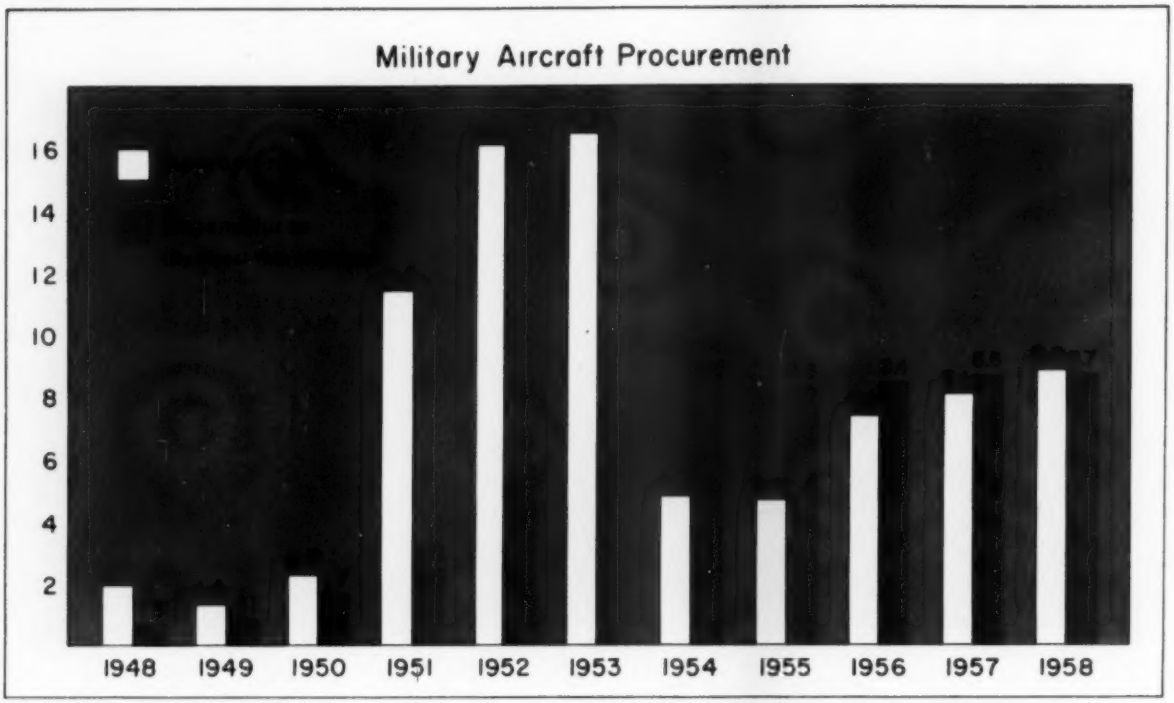


New USAF Concepts Test Producers

By Claude Witze

The American aircraft industry, development and production partner of the U.S. Airforce, inevitably faces greater challenges from its customers each year. Fiscal 1958 will be no exception.

Next year's budget, as proposed by the Defense Department, contemplates that orders will be placed for only 1,500 USAF planes. They will be expensive pieces of hardware, costing almost as much as Fiscal 1957's 1,900 aircraft. The merits of this program will be weighed in the next few weeks by Congress. If there are any changes, they will be minor, and the thesis remains—the industry now faces a revolution in production.

Gen. Nathan F. Twining, USAF Chief of Staff, recently pointed out that in 1954 missiles took only 10% of his procurement funds. For 1958, the estimate is 35%. By the 1960s, the General says, pilotless weapon systems will take half of USAF's procurement funds. While it is true that a large amount of this money will go into development and add nothing to our operational capability, production facilities and know-how must come out of industry talent in the intervening years.

Maj. Gen. David Baker, procurement chief of the Air Materiel Command, has predicted that the impact of this change-over will be as great or greater than that experienced in the shift from Signal Corps observation missions to combat in the air.

Missile construction is basically the same as aircraft airframe construction. Introduction of highly complex electronic components and more advanced propulsion units will duplicate in many respects the experiences of veteran weapon system designers and builders. The problems will simply be tougher, and there will be more of them.

Take the matter of complexity. The Century-series fighters and bombers like the Boeing B-52 resulted in new problems for designers, production line experts and USAF maintenance crews. Missile complexity will compound the problems mainly because they must be 100% reliable the instant they are called upon for action.

Moreover, the call for action in many cases must be part of the weapon system itself. It is not enough to have an interceptor that will go into the air after the siren blows to start a scramble. Detection, warning, tracking, aiming, firing, guidance control and the kill all must be part of a guided missile weapon system.

A large part of this lies outside the traditional realm of our aircraft industry.

It may be that this necessary integration of previous strangers into the aircraft industry complex is the most important part of the revolution now in the making. USAF has been saying for a number of years that it depends upon its contractors alone for technical talent, knowing full well that no military service can do the job.

USAF Needs

Gen Baker has outlined a few of the requirements he thinks the industry should be studying right now:

- **Greater automation** to speed production.
- **New requirements** for highly skilled personnel.
- **New materials,** production techniques and manufacturing methods.
- **More intimate cooperation** between the aircraft industry and the people

Force Levels

The following military airpower force levels are scheduled to be reached by the end of Fiscal 1958:

USAF—128 wings

NAVY—17 carrier air groups
20 anti-submarine squadrons
3 Marine air wings

ARMY—5,031 aircraft

U. S. Plane Inventory

(End of fiscal year)

	1957	1958
USAF	26,736	24,398
NAVY	12,576	11,790
ARMY	3,954	5,031
TOTAL	43,226	41,219

Budget Shrinks USAF Goal

With presentation of its proposed Fiscal 1958 budget, the Defense Department disclosed its abandonment of the 137-wing goal for USAF, a strength it was scheduled to reach by next June 30.

Defense spokesmen say the new goal will be 128 wings and contend that overall strength will not be impaired because weapon systems are improving. In addition, the number of B-52 intercontinental jet bombers in each wing has been increased from 30 to 45.

The 128-wing figure includes five wings not previously counted as part of USAF's force structure. They are four assault transport wings, including the Fairchild C-123, and one Matador guided missile wing. USAF slashes include:

- **Tactical Air Command: Six wings; one B-45 medium bomber, two fighter-bomber and three day-fighter.**
- **Air Defense Command: Two fighter-interceptor wings, planned but never activated.**
- **Strategic Air Command: Six fighter wings.**

Specific aircraft that face a cutback in previously planned production includes the McDonnell F-101B, Lockheed F-104A, Republic F-105, and Martin B-68 tactical bomber.

who engineer and build missile system components.

The last item is important from both a practical viewpoint and because it is one of the vital parts of USAF policy. The practical angle: AMC will be forced, as it superintends the production of guided missiles, to withdraw to some degree from its system or providing Government Furnished Aeronautical Equipment.

Some items will remain GFAE, of course. Propulsion is a likely example. However, the prime contractor is going to be saddled with greater responsibilities in the assembly of a complete weapon system.

Lt. Gen. Clarence S. Irvine, Deputy Chief of Staff for Materiel, says that if the industry wants to stay abreast of USAF requirements it must exploit every bit of engineering and production know-how available in America. To USAF, and the Defense Department, this is the only way to properly utilize the industrial potential.

"It permits us," Gen. Irvine says, "to maintain a reasonable level of production with economy for the long haul. In effect, we are tailoring the production base so that it can respond effectively to an emergency of any scale."

Prime Contractor Selection

Gen. Irvine has a tough attitude toward the prime contractor. With a philosophy that can be traced back to Roger Lewis, former USAF assistant secretary for materiel, the General looks to only a few companies when he is selecting a weapon system prime contractor. The competition, he says, is so keen it is almost bitter. And once the selection is made, the contractor is responsible for everything, including a paramount responsibility that can make giants tremble—performance reliability.

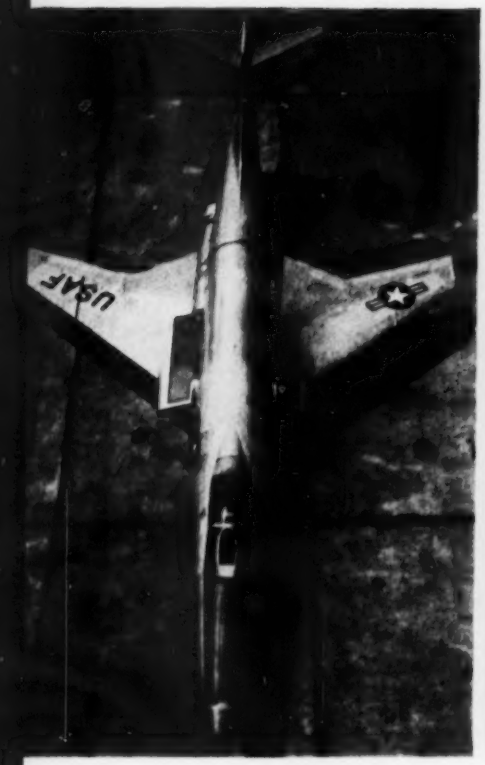
There is still a place for the subcontractor and small business. Says Gen. Irvine:

"Some people have the mistaken belief that once a prime contractor is selected, he has the concurrent authority to tool up and produce all component parts and subsystems. The Air Force view diametrically opposes such a belief and will actively discourage prime contractors from expanding their facilities and enabling themselves to self-produce what they could subcontract."

For both primes and subcontractors, the advent of real missile production will again introduce the whole problem of facilities.

Real estate, bricks and mortar and machinery will have to fit the job. Some

B-52 WITH F-100, F-101 AND F-102 ESCORTS



McDONNELL RF-101A

of the older plants are simply not adaptable to missile or missile component fabrication.

There are some cases where an aircraft plant has been made to do by the addition of air conditioning and humidity control, but the high bay areas common in major aircraft plants are on, or over, the economic margin where money can be invested in this kind of an alteration. Moreover, for the most part, high bays are not needed for missile production.

A forerunner of this problem is the case of the Convair B-58 supersonic bomber which will be built in the Ft. Worth plant that a decade ago was producing B-36 bombers.

Three B-58s can fit in the floor space occupied by a single B-36, and the ceiling could be lowered a good many feet. In addition, the B-58 is a "dense" aircraft, jammed with electronic equipment sensitive to the atmosphere. It requires a vastly different kind of tooling and equipment that would work more efficiently if the plant had not been designed on gargantuan lines.

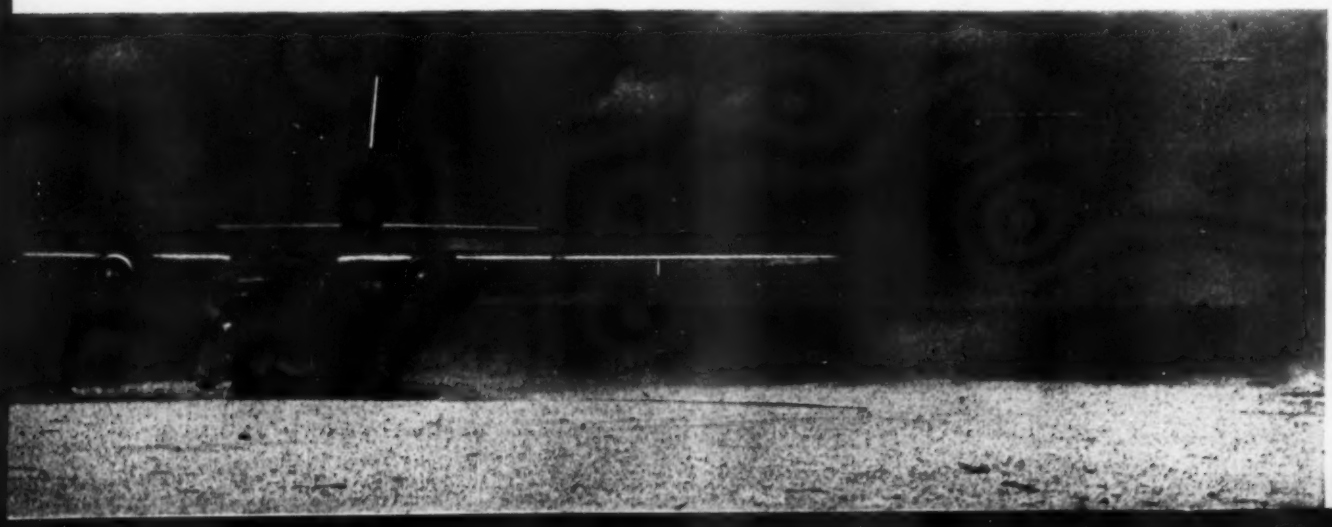
New Plants for Missiles

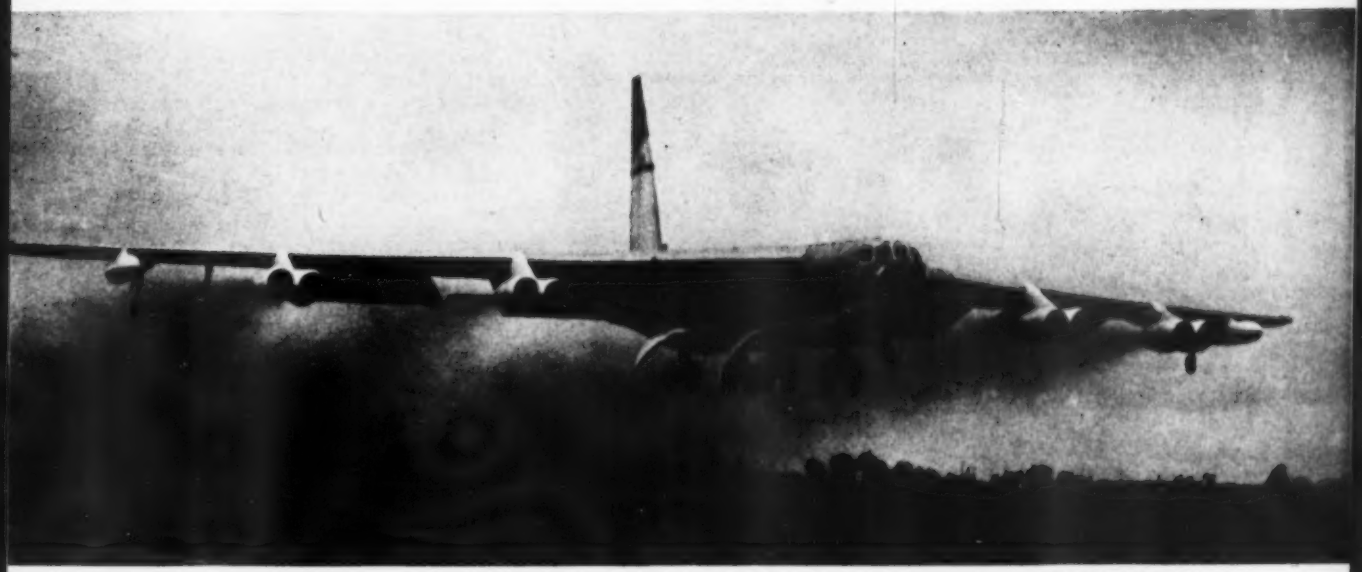
The bluntest USAF observers say that the new plants are needed for the missile era. The Air Force feels strongly that outdated high-bay plants should be disposed of because it costs almost as much to adapt them as it does to build from the ground up.

Also, the industry can look for no letup in USAF's stern attitude toward financing plant construction. It is clear that the official attitude is one of letting the firms that are competent and confident provide their own factories.

The Air Force is prepared to help in one important way. It will defend the present fast tax amortization system that permits a defense contractor to write off cost of such facilities in about five years.

FAIRCHILD C-123





BOEING B-52

Some top USAF officers are frankly worried by what they detect as a trend in the present administration to curtail this privilege.

The amortization system and renegotiation have the two-pronged virture of encouraging manufacturers to provide facilities and giving USAF some control over their location. At the same time, the economic environment of business today is viewed as an asset, providing more encouragement to those efficient producers who see a high return on their investment if they abandon World War II thinking and push self-financed construction plans.

A word of caution is necessary, and it is provided by the best-qualified man, Maj. Gen. Bernard A. Schriever, chief of the Western Development Division. He says missile firing successes still are the exception rather than the rule.

Missiles on Hand

Gen. Schriever has expressed some concern over the reasonably wide-spread public impression that we have more and better missiles in the inventory than is the case. He stresses these points:

- **Guided missiles** are in their infancy and subject to growing pains.
- **There is no** all-purpose missile.
- **USAF requires** the largest variety of missiles.

Actually, USAF has only two operational missile systems that are available in quantity for immediate use in case of an emergency. They are the Hughes Falcon GAR-1 used on the Convair F-102 and Northrop F-89 interceptors, and the Martin Matador, a subsonic pilotless jet plane. The Falcon is capable of stopping a bomber, at least when fired in salvo. The Matador is vulnerable to interception but it can carry a warhead several hundred miles.

Future Missiles

Other USAF missile projects:

- **Boeing Bomarc IM-99,** an interceptor nearing operational readiness. The Bomarc is an area defense weapon like the Army's Nike, but with longer range.
- **Bell Rascal,** which will be launched from a manned bomber such as the B-47 or B-52 to hit surface targets.
- **Northrop Snark SM-62.** The Snark is similar to the Matador but has longer range.
- **North American Navaho** is similar to Snark but supersonic.
- **Convair Atlas** intercontinental ballistic missile.
- **Martin Titan,** a competitor of Atlas but with a different design approach.
- **Douglas Thor** intermediate range ballistic missile. It is now ready for flight test and competes with Army's Jupiter.

For this entire program in Fiscal 1958, the proposed budget would allocate $1,793 million. Further details on the state of the art are in the Missile Engineering section of this Inventory issue of AVIATION WEEK.

The manned aircraft that will be ordered in Fiscal 1958 will include almost no transports or trainers. Bulk of the $4,519 million sought in new obligational authority will go for big and expensive jet bombers and tankers, the Boeing B-52 and KC-135.

No Interim Aircraft

Of major concern to USAF is the lack of plans for interim aircraft to fill the probable gap that will exist between ICBM. And the Century Series fighters may be obsolete before there are unmanned systems to replace them.

This decision presumably stems from the USAF conviction, reiterated recently by Secretary Donald A. Quarles, that "we must make sure that first things come first—winning the initial violent air-atomic battle must always be our first priority."

The Fiscal 1958 buying program is viewed by the administration as the first step toward insuring that the priority will be met. Others, according to Quarles, are that we must be selective in the way we use the resources at our

USAF Planes on Hand

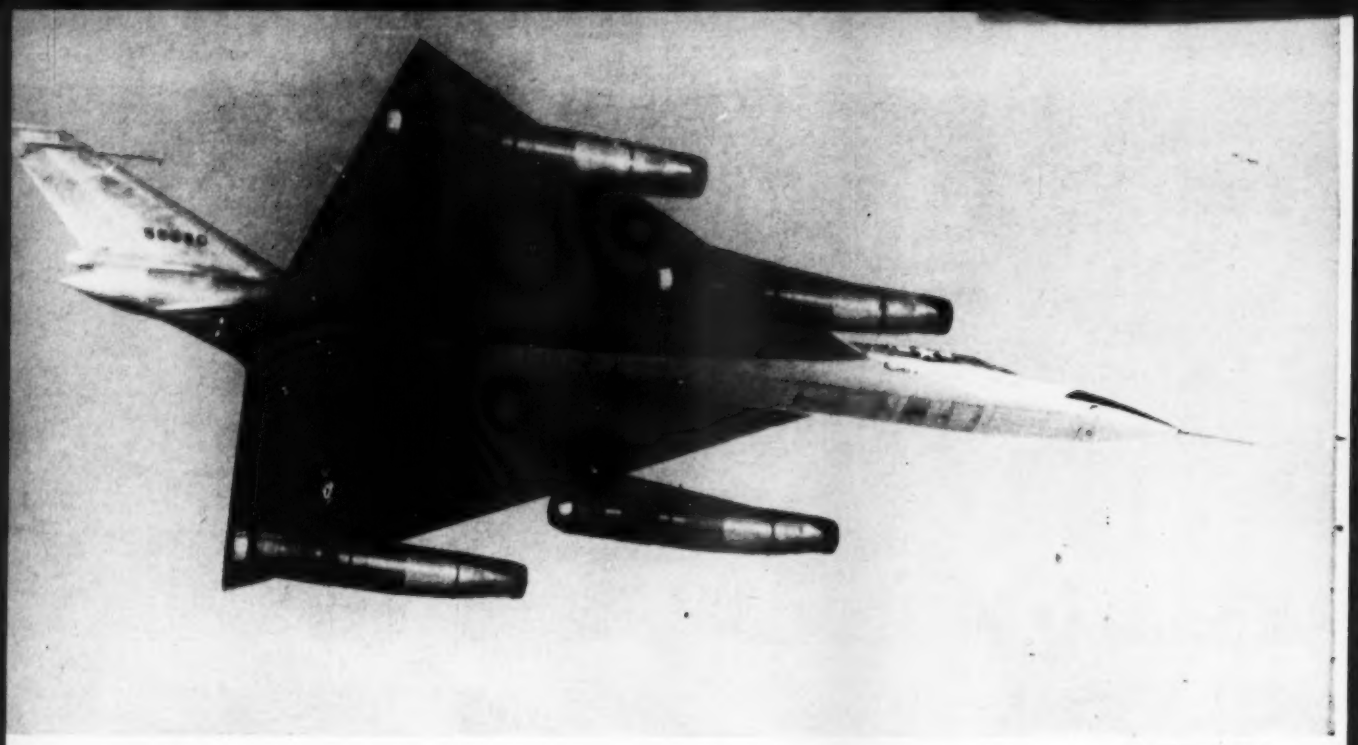
1956	18,597
1953	35,804
1954	44,532
1955	72,726
1956	44,783
1957	50,636
1958	23,614
1959	20,068
1960	17,232
1961	17,237
1962	20,000*
1963	26,000**
1964	23,300***
1965	22,400
1966	23,579
1967	24,987

Note: All figures are as of Jan. 1 except 1957 which is as of November 1956.

* Includes 16,000 in active inventory and 4,000 inactive.

** Includes 16,500 active and 4,000 inactive.

*** Includes 17,700 active and 4,600 inactive.



CONVAIR B-58

USAF Aircraft on Order

Aircraft Type	Popular Name	Manufacturer
	Bombers	
B-47E	Stratojet	Boeing
B-52D	Stratofortress	Boeing
B-66B	None	Douglas
RB-66C	None	Douglas
	Fighters	
F-100D	Super Sabre	North American
F-100F	Super Sabre	North American
F-101A	Voodoo	McDonnell
F-101B	Voodoo	McDonnell
RF-101	Voodoo	McDonnell
F-102A	None	Convair
TF-102A	None	Convair
F-104A	Starfighter	Lockheed
F-104B	Starfighter	Lockheed
F-105B	None	Republic
F-106A	None	Convair
F-106B	None	Convair
	Transports	
C-130A	Hercules	Lockheed
C-133A	None	Douglas
KC-135A	Stratotanker	Boeing
C-123B	Avitruc	Fairchild
Cessna 310	None	Cessna
	Trainers	
T-33A	Shooting Star	Lockheed
T-37A	None	Cessna
	Helicopter	
H-21B	Workhorse	Vertol

disposal, the projects we support, the bases we build and the kind of forces we maintain.

Wing Dispersal

Within USAF, there are other operational facets. One of these is the struggle to have easier maintenance built into weapon systems right from the design stage. Maj. Gen. A. G. Hewitt, a member of Gen Irvine's staff, reports progress in this direction, but the pressure on contractors will be continued.

Another, far removed from the area of procurement, is a program designed to frustrate the enemy.

The general idea is that our Air Force today is too vulnerable to atomic attack. Heavy jet bomber wings, consisting of 45 B-52 aircraft, are going to be divided so that only one squadron remains on the parent base, while two squadrons operate from satellite fields with limited facilities. In addition, other airfields will be used for emergency staging and dispersal.

Industry also is going to feel the effect of this effort. Dispersal of new plants and dispersal of the contracts placed in both new and old plants are part of USAF's policy.

Cutting Lead Time

While the emphasis today is upon the changing character of the Air Force, the shift to missiles and what it means to industry, USAF's main concern of a year ago—the huge technological strides taken by Soviet Russia—is still a dominant factor.

The race, in fact, is more serious than it was a year ago. Major activity of 1956 bearing on this subject was the detailed analysis of the military aircraft development cycle performed by the Defense Department's Aircraft Study Group.

The committee drafted a long list of recommendations, designed to shorten the cycle from concept to inventory and USAF—as well as the Army and Navy—has been challenged to implement them as soon as possible.

There are some signs of strife over the study group's proposal that the U. S. must reduce the amount of time spent getting operational hardware out of a new concept. Quarles himself has declared that "drawing board to inventory lead time is not in itself a good measure of the effectiveness of development effort."

Comparing the long lead time of the B-52—eight years—with the four or five years required by the Russians to develop the Bison bomber, Quarles comes to this conclusion:

"The B-52 is a substantially more advanced and higher performance weapon system than the Bison. It seems fair to conclude that the development interval, whether it is four years or eight years, is a minor rather than a major consideration."

Progress in 'Big Steps'

In this, the secretary agrees with Lt. Gen. Thomas S. Power, chief of the Air Research and Development Command, that we must make our progress

in "big steps." He also appears at odds with the general belief that we must shorten our cycle to meet Red competition, an assumption that generated the Aircraft Study Group's assignment in the first place.

It is difficult to avoid the conclusion that budget considerations help shape USAF's attitude on this question.

There is no doubt that "little steps" or frequent small improvements do not lend themselves to economical production or equipment conversion. On the other hand, while the Aircraft Study Group report remains blanketed by secrecy, there can be little question that it is concerned with shortening the cycle when we are taking big steps as well as little ones.

Cost of Superiority

Main point in the technological crisis is that the Russians are closing the gap and closing it fast. Staying in front is bound to cost money and, for this reason, the nation's top experts believe we must spend substantially more for the research and development effort.

As a year ago, it is virtually certain that USAF material deliveries will remain in the $6 to $7 billion a year bracket for some time to come. It is the nature of the hardware that will change.

In addition to the switch to guided missiles, a healthy slice of this money will find its way into high priced modernization programs, airbase equipment and such expensive USAF items as the DEW line and SAGE warning system.

Operating costs are snowballing far beyond the limits once imagined by the Air Force.

This means that the aircraft industry, USAF's partner with a major responsibility, must produce more for less. There are major hurdles to cross between now and 1960.

DOUGLAS B-66

Primary Asset

Primary asset of the aircraft industry that will be watched by USAF in 1957 is its manpower and how it is used.

Lt. Gen. Clarence Irvine, Deputy Chief of Staff for Materiel, warns that the industry is "asking for some form of dictatorship" if it fails to use available skills for the greatest benefit of its customer.

"In too many companies," Gen. Irvine says, "the tempo is a good deal like glue running uphill." He also says he suspects there is too much of the "university atmosphere," and that there is hoarding of engineers, scientists and skilled technicians. He emphasizes that USAF procurement officials will examine the quality of industry company staffs, not merely the size of them.

Gen. Orval R. Cook, one of Gen. Irvine's predecessors and now president of the Aircraft Industries Assn., says he shares some of the Air Force feeling that engineers in aircraft plants are not as busy as they should be.

Gen. Cook believes the engineering shortage is "acute only in the category of specialized scientific and engineering talent which always has been in great demand. He does not anticipate any reduction in the demand for this kind of talent.

With an eye on possible congressional action, Gen. Cook reports that most companies plan to expand their training programs for production workers. He says the skill level in the open labor market is declining.

In addition, technological advances have outdated the training of many workers now on the industry payroll. For this reason, new skills and techniques must be acquired as the industry's workers turn from conventional aircraft to the customer's demand for guided missiles and other complex equipment.

LOCKHEED F-104B

DOUGLAS F5D-1

Navy Sells Seapower's Role in Nuclear

By Evert Clark

Navy is moving into another year of what Adm. Arleigh Burke calls its "period of tremendous transition" with excellent prospects.

Aircraft, missile and shipbuilding programs are producing highly effective hardware—and Navy's aggressive leadership has put this technical progress to expert use in selling the idea that seapower has a vital role in the nuclear-missile age.

Carefully avoiding criticism of budget policies, the Navy has concentrated instead on the positive approach—setting records, demonstrating at every opportunity the range of its potential striking power and capitalizing on events such as the Suez crisis to argue the importance of free shipping lanes and the versatility of a mobile force that can be called in to deter aggression with anything from its mere presence to the use of its full fighting strength.

At least partly as a result of this progress, plus salesmanship, the Navy has come through a year of adjustment and realignment of roles, missions and weapons assignments with fewer losses than the other services.

It is very nearly ready to cross what Chief of Naval Operations Burke refers to as "the threshold of the nuclear-missile age."

The power of Russia's submarine fleet—recently placed at 500-600 by Navy Undersecretary for Air Garrison Norton—has been more widely recognized, and anti-submarine warfare has been given the highest priority.

Research and development in aircraft, and in some missile work, has been streamlined (AW Oct. 1, p. 26), and the shift to nuclear powerplants for ships and submarines has been speeded.

Navy's New Aircraft

Past effort is paying off with these new aircraft:

• **Chance Vought F8U-1 Crusader.** Powered by the 10,000-lb. thrust Pratt & Whitney J57, the Crusader fighter last year captured the Thompson Trophy with a speed of 1,015 mph. (AW Aug. 27, p. 27). The first squadron of 12 planes will go into service after completion of tests at the Naval Air Test Center, Patuxent River, Md., this spring. An improved version, aimed at speeds of about Mach 2, is being developed (AW Jan. 14, p. 23). Its designation will be F8U-3 and it is still three years away. A photographic version of the Crusader, the F8U-1P, is now in the Fleet Introduction Program.

• **Grumman F11F-1F Tiger.** Although there are only two models of this improved Tiger, its General Electric J79 engine has pushed the F11F-1F to 1,220 mph. in level flight and to an altitude of 72,000 ft. (AW Dec. 24, p. 26). Grumman has asked to make an official try at both the world's speed and altitude records.

• **Douglas F5D Skylancer.** Equipped with the Pratt & Whitney J57 and designed for greater speed, range and performance than the similar F4D Skyray, the Skylancer is now limited to 11 models. Navy says development will continue "for the time being" as insurance. Although cutback in orders from 19 to 11 was primarily budgetary, the Navy apparently feels the F5D might be superseded by some other aircraft within a year to a year and a half after it got into service.

• **North American FJ-4B.** Powered by the Curtiss-Wright J65, this advanced Fury is designed as an attack and dive bomber with fighter performance and atomic bomb delivery capability. It will be in quantity production by mid-spring and will replace FJ-4s.

• **McDonnell F4H.** This twin-engine, all-weather fighter-attack bomber (AW June 18, p. 23) designed for Mach 2 speeds will be powered by General

FAIRCHILD PETREL ON LOCKHEED P2V6-B

Missile Age

Electric J79s. First rollout originally was scheduled for May.

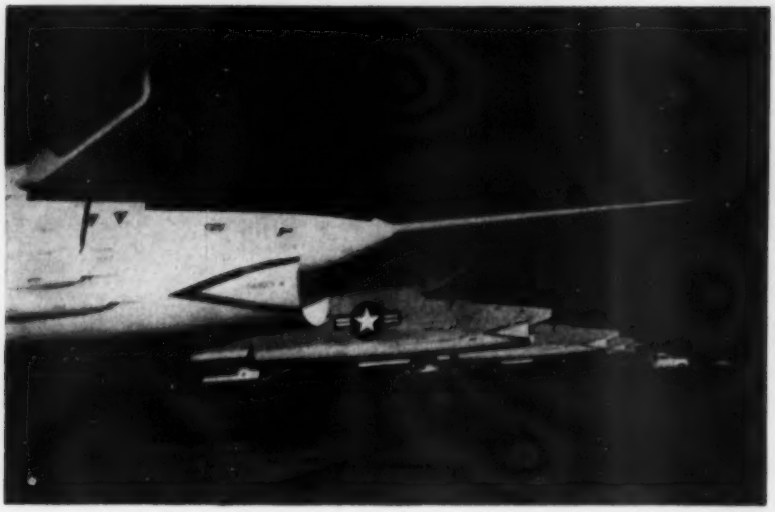
• **McDonnell F3H-2M Demon.** This version is a day fighter armed with 20mm. cannons and Sparrow I missiles. It now is beginning to come off the production line, joining the F3H-2N, the all-weather version which carries guns and the Sidewinder missile. Ultimate version of the Demon, designated the F3H-2, is still in development. It will be an all-weather fighter carrying what the Navy calls an "all-weather missile"—probably Sparrow III. All three Demons are powered by the Allison J71.

• **Douglas F4D Skyray.** More than 100 of these all-weather fighters, powered by the Pratt & Whitney J57, already are in the fleet but quantity production will continue to mid-1958.

• **Douglas A3D-2 Skywarrior.** Still in development, this advanced version of the A3D has undergone flight test trials at Edwards AFB. Powered by two J57s, the heavy-attack A3D was used at the National Aircraft Show last September to demonstrate Navy's inland penetration ability from carriers (AW Sept. 10, p. 30). There is a photo-reconnaissance version, A3D-2P, and the Navy is considering a radar countermeasures version, the A3D-2Q (AW Apr. 16, p. 23).

• **Douglas A4D-2 Skyhawk.** This advanced small attack bomber is being delivered, and the A4D-3, with much longer range and improved bombing and navigation capability, is in develop-

DOUGLAS A3Ds ON USS FORRESTAL



CHANCE VOUGHT F8Us

ment. Metal has not yet been cut. A4D-3 will be powered by the Pratt & Whitney J52 instead of the Curtiss-Wright J65 now powering A4Ds.

• **North American A3J.** North American's Columbus Division holds an $86 million research and development contract for a two-place, twin-jet "high supersonic, carrier-based attack aircraft weapon system." It will be powered by the J79 (AW Sept. 24, p. 28). This is the first Navy aircraft to be designated as a weapon system.

• **Grumman F9F-8T,** Navy's first operational transonic trainer, is in production, and delivery is due in early spring. A stretched version of the Cougar, the F9F-8T is powered by the Pratt & Whitney J48.

• **North American T2J.** This jet basic trainer (AW July 23, p. 28), powered by the 3,400-lb. thrust Westinghouse J34, is in production, and delivery is expected in December.

• **Temco TT-1.** The Navy is buying 14 of these primary jet trainers for evaluation, powered by Continental J69.

• **Lockheed W2V.** The W2V essentially is an improved WV-2 Constellation early warning radar aircraft with a disk-shaped, plastic rotodome mounted atop the upper radome. It still is in development, and Air Force also is interested.

New Version of Tracker

In addition to these, Grumman is building an early warning version of the anti-submarine S2F-1 Tracker. It is designated WF-2 and carries a large oval radome similar to that on the W2V (AW Jan. 7, p. 23).

Grumman, Martin and Convair are competing on an anti-submarine warfare design, and Grumman has a $24 million order for TF-1 Traders—the utility-cargo version of the Tracker. It will be used for carrier resupply. Deliveries of three a month are to begin next November.

Lockheed has a $70 million production contract for Navy's 600 mph. boundary layer control T2V-1 SeaStar jet trainer. This will carry production of the SeaStar through 1958.

A vertical takeoff jet fighter competition is now on.

Missile Progress

The Navy, which likes to point to the fact that it has operational missiles in all four of its categories, can report impressive progress in the missile field.

• **Air-to-Air.** Sparrow I, a supersonic beam-rider built by Sperry-Rand is arming Chance Vought F7U-3M Cutlasses and McDonnell F3H-2M Demons. The Douglas Sparrow II is not in quantity production, but the Raytheon Sparrow III, a fully-active homing missile, will be produced by Raytheon in Sperry's Farragut plant at Bristol, Tenn., probably beginning this spring. Raytheon also is developing two new versions of the Sparrow for new aircraft (AW Dec. 31, p. 23).

The Navy also has Sidewinder, a Mach 2-plus infrared homer now arming squadrons in the Sixth and Seventh Fleets. Philco and General Electric are producing it for both the Navy and Air Force. Another project under development is the Diamondback, probably a heat-seeker.

• **Surface-to-Air.** The beam-riding Convair Terrier already arms the cruisers Boston and Canberra and the guided missile destroyer Gyatt. The first of 16 of its type, Gyatt was commissioned last December.

Talos, a 10-ft. ramjet anti-aircraft missile with twice Terrier's range, will go to sea early next year on the converted cruiser Galveston.

Tartar, a 12-ft. improved Terrier with a homing head, should appear in the fleet in 1960, replacing 5-in. guns on some destroyers and cruisers.

• **Surface-to-Surface.** Regulus I, a subsonic missile powered by the Allison J33 engine, is aboard 10 carriers, four cruisers and the submarines Tunny and Barbero. The supersonic Regulus II, to be powered by the Pratt & Whitney J57, has been ordered into production (AW Dec. 17, p. 34). It is well ahead of schedule.

The Navy also is developing its own seagoing ballistic missile, the Polaris (AW Jan. 7, p. 32), with Lockheed Aircraft Corp. as the prime contractor and with General Electric, Aerojet-General and Massachusetts Institute of Technology participating. It will be a comparatively short, squat, solid-propellant missile for shipboard and submarine firing. The Navy also has under development with McDonnell the surface-to-surface ramjet Triton, (AW Oct. 8, p. 23), which may have a design speed as high as Mach 4.

• **Air-to-Surface.** The Fairchild Petrel,

LOCKHEED WV-2

virtually a Mk. 13 torpedo with wings and a Fairchild J44 engine, is used for ship attack from more than five miles away. It is carried on the P2V-6B, P5M-2B, and an HSL helicopter. A radar altimeter checks height above water and jettisons flying surfaces and engine before the final run to target, which is made with a fully active homing head (AW Apr. 9, p. 33).

Navy also has its air-dropped atomic anti-submarine weapon, the Lulu, and a missile designated Bulldog. Weapon Able, shown in Navy photographs (AW Nov. 12, 1956, p. 123), and Lulu may be the same.

First Atomic Carrier

Navy force levels call for 15 attack carriers and five reserve carriers, plus nine anti-submarine carriers. The Fiscal 1958 budget requests $14.6 million for 19 new ships and 12 conversions.

New ships include the first atomic carrier, 13 destroyers and frigates and four more nuclear-powered submarines. The conversions include putting an angle deck on the Oriskany, making radar pickets of four merchant hulls and converting one seaplane tender, three missile cruisers and three surveying ships, the last for studies of the ocean's bottom.

The degree to which the Navy is being "missilized" is apparent in the plans for missiles developed from the Bumblebee program.

By the end of Fiscal 1961, Navy will have two heavy guided missile cruisers, one destroyer, seven light guided missile cruisers and 12 destroyer-leaders equipped with Terriers; 17 guided missile destroyers equipped with Tartars and seven light cruiser conversions equipped with Talos. This does not take into account the Polaris or Triton.

Anti-Submarine Research

On the research and development side, the Navy has given anti-submarine warfare its highest priority. Detection, identification and long-range kill—with the emphasis on long-range—are the problem areas.

The Navy sees the Russian submarine fleet primarily as a weapon to isolate Europe and Asia from U. S. shipping in an all-out war and to keep our carrier forces from getting within striking distance of the Eurasian continent. But it also recognizes the powerful threat that the missile-launching submarine represents to this continent. Russia is believed to be concentrating on the so-called W-class long-range submarines for operation in the Western Atlantic.

Research in anti-submarine warfare (ASW) is across the board and was spurred considerably, along with all

Navy research, by the Lamplight and Killian studies. As a result of these studies, the Navy initiated 95 new developments in radar, communications, data processing, countermeasures, aircraft, missile and ASW fields.

In addition to meeting the submarine threat, the Navy—and particularly the Bureau of Aeronautics—is emphasizing these areas of research and development:

- **Long-range missiles.** The goal is to reach the point where manned aircraft do not have to fly over enemy areas.
- **Air-launched missiles.** Although the Navy has no aircraft-pod concept, similar to the Air Force's B-58, it is seeking more "stand-off" capability in its aircraft wherein the plane fires from longer and longer distances from the target.
- **Rocket engines.** Speed and altitude limitations of turbojets have led to work on rocket-augmented jet planes. Two prototypes—an F8U and an FJ-4—are now being tested with rocket engines.
- **Aerodynamic heating** and stability and control above Mach 2.
- **Physiological aspects** of high-speed, high-altitude flight, including survival problems. The Navy is working with clamshell seats and cockpit capsules. Also in this field are improved pressure suits and the simplified presentation of flight data.
- **Zero-altitude ejection.**
- **Improved blind (all-weather) attack** and low-altitude attack capabilities.
- **Vertical takeoff and landing.** Especially important to the Marine Corps, with its concepts of mobility and of "vertical envelopment" of an enemy, this development is interesting the Navy more and more for both shipboard and land application. The Navy has helped support the USAF-Ryan Vertijet project and has other VTOL projects with Ryan, Vertol and Piasecki.
- **Improved catapults,** both steam and internal combustion, and improved arresting gear. Marine Corps' interest in transportable catapults is as strong as its need for land-based arresters.

Mirror landing systems, already programmed for all angle-deck carriers, are now going into all Navy fields.

'Buddy System' Progressing

Work on the "buddy system" for refueling is progressing, although the system is still not in service. When it is, most carrier planes will have potential refueling capability. The buddy system calls for one plane of a type—the A4D, for instance—to refuel another A4D, using pods and droppable tanks.

The F8U-1 will be a receiver only. Newer planes, including the upcoming A3J, will be both tankers and receivers.

Despite the crashes of two experimental prototypes, work on the Martin P6M SeaMaster is going ahead. The Navy apparently anticipates no cutback in the original order for six test models and 24 production models. The P6M will be a minelayer and attack bomber, with low-altitude capability. The third test model may be ready to fly soon.

The SeaMaster has no direct relationship to the aircraft nuclear propulsion program, but Navy researchers consider it a stepping-stone, particularly as far as the airframe is concerned, in this field.

VERTOL H-21s

Policy-Bound Army Hunts Air Tools

U.S. Army Aviation in 1957 is still struggling for recognition and the freedom to develop special aeronautical tools for the job it has to do.

It is not making progress on all fronts.

In addition to restrictions placed upon it by Defense Department decree, Army Aviation has some new problems traceable in part to the changing concept of what the Army's force structure must be in a nuclear ground war. This year, the Army will reorganize its divisions, cutting them in numerical strength and improving their combat effectiveness.

So far as the aviation elements of the Army are concerned, this decision puts planners in the position of tailoring a suit to fit a man whose height and waistband measurements are going to change any minute. No one knows which way they will go.

Meanwhile, Army Aviation is working to freeze a six-year program, which is exactly what it was doing a year ago. Maj. Gen. Hamilton H. Howze, director of Army Aviation, says frankly that his people are still "feeling their way."

The Army's new Combat Developments Test and Experimentation Center at Fort Ord, Calif., will help Gen. Howze explore the utility of aircraft in the light of the new streamlined combat division.

Program for Industry

There are indications that the shakeup of the Army's organization and work at the Fort Ord center will lead to further alterations in aviation planning. Gen. Howze can outline a broad program showing what he expects from the aircraft industry in the next few years. At the same time, he acknowledges there is a lot to learn about the real demands.

An example of this is the relatively recent abandonment of Army enthusiasm for huge helicopters. The Vertol H-16 Transporter project has been dropped after a long and expensive development history. The number of cargo helicopter companies planned by the Army has been reduced.

Gen. Howze says the Army now leans toward smaller helicopters. They are more practical from the viewpoint of the soldier, the maintenance crews and auditors who look upon expensive hardware with a cold eye. It is likely that this approach is responsible for Army's more or less quiet acceptance of a Defense Department order that it must not buy helicopters of more than 20,000 lb. gross weight.

R&D Strengthened

Major step toward strong management of Army's aeronautical research and development was taken last fall when it put basic responsibility for this work in the hands of TRADCOM, the Transportation Research and Development Command, located at Ft. Eustis, Va.

TRADCOM's Aviation Division is being enlarged, and the office now intends to do its own research and development contracting, independent of Air Force and Navy, on any projects with major application to Army missions.

Gen. Howze has put down these two broad goals for Army Aviation development efforts:

DE HAVILLAND U1-A OTTERS

Atomic War

• **Fixed-wing aircraft** must have shorter takeoff and landing capabilities, greater capacity and higher performance.
• **Rotary-wing aircraft** must have simpler design, higher payloads and lower maintenance cost.

It is obvious both of these requirements are no development of recent months.

In a general sense, they cover the improved performance and lower cost that have been everyone's goal since 1903. The sharp truth is that Army Aviation needs them for survival. Economically sensible helicopters and fixed-wing planes with almost fantastic performance characteristics are essential to keep the Army in the air.

What Army Wants

The basic idea is that an airplane is a vehicle. There is no reason, from the Army's viewpoint, why the vehicle should operate from airports, fly any higher than the trees or any faster than a good efficient truck out of Detroit. And the cheaper the better.

The point is illustrated by the award last summer of a contract to Ryan Aeronautical Co. for the design and development of a deflected slipstream, turbine-powered, vertical takeoff and landing aircraft (VTOL). Another example is the flying crane, a project now in the hands of several manufacturers. It will be a helicopter without a fuselage capable of picking up a tank, a section of bridge or a heavy missile and moving it across a river or other barrier.

Gen. Howze has suggested some other items that may find a place in his stable of specialized aircraft:

• **Higher performance observation** aircraft capable of carrying electronic gear over a battlefield for surveillance. It must have a speed of 275 to 300 kt. and be able to land and take off over a 50-ft. obstacle within 600 ft. While this plane's weight probably will exceed the 5,000 lb. limitations ordered by the Defense Department, an exception has been granted to permit development of the aircraft.

Other exceptions are expected for specialized aircraft.

• **Fixed-wing cargo aircraft** that can carry 2½ tons. It must cruise at 200 kts. and operate over a 50-ft. obstacle at 500 ft.

A second plane is being considered that can haul a four-ton payload under the same circumstances as the 2½-ton type.

KAMAN HOK-1

• **Light, simple observation** helicopter to be procured on a large scale. It must be small and cost about one-third of present models. There will be a design competition for this vehicle this year.
• **New utility helicopter,** which is the Bell H-40. It will cruise at 100 kt. and carry a payload of 1,000 lb. Powered by turbine engines, it will be available in 1959.
• **Medium cargo helicopter** also powered by turbines. It must have a payload of three tons.
• **One-man "lift-device"** such as the

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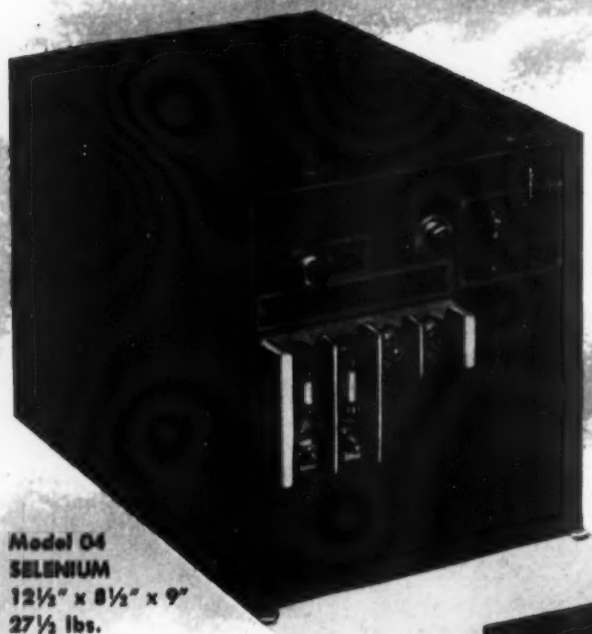

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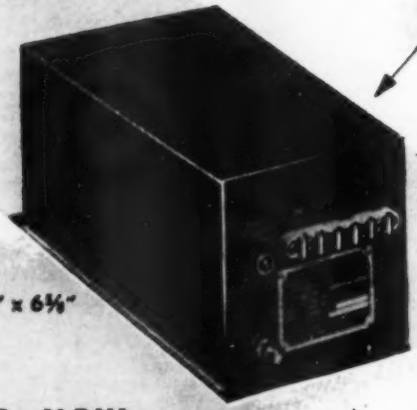

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DeLackner Aerocycle or Hiller Flying Platform. This could be used for patrols, messengers and reconnaissance, once the bugs are ironed out and current evaluations completed. Test programs have been started on both models.

• **A larger "lift device"** called the "aerial jeep." It would have a payload of about 1,000 lb. and carry radio equipment and armament.

Increasing Mobility

All of these vehicles continue to emphasize Army's insistent interest in mobility, which is one of the things its new streamlined divisions must have. A top artillery officer has outlined some ideas of how they can be employed:

• **Integrated** into combat and service organizations wherever mobility will be improved or combat effectiveness increased.

• **Replace ground** vehicles in tactical units wherever mobility and combat procedures will be improved.

• **Organization of super-mobile** airphibious-type combat organizations equipped with aerial vehicles instead of ground vehicles.

Present Aircraft Inadequate

It is clear, so far, that existing equipment is not adequate. By next Dec. 31, the Army will have more than 4,500 aircraft, practically none of which represent a substantial step toward its necessary goals.

For obligation to the industry in Fiscal 1958, it seeks $82 million in new authority but will be able to sign contracts for as much as $124 million if the request is granted by Congress. This is possible because it has obligational authority left over from previous years.

At the beginning of 1957, the Army had 15 transport helicopter companies. Each company includes 21 cargo helicopters, the Vertol H-21 or Sikorsky H-34. There are three tactical fixed-wing transport companies, each equipped with 21 de Havilland U-1 cargo planes.

Flight Training

Army Aviation has assumed responsibility for all phases of its training program, another innovation of the past 12 months. Primary flight instruction for fixed-wing pilots is being conducted at Gary Air Base, San Marcos, Texas, by a civilian contractor under the eye of an Army quality control group headed by Col. Jules Gonseth. The establishment will train about 1,200 Army officers this year.

Pre-flight and primary flight training for rotary-wing pilots is being conducted at Camp Wolters, Texas, by another contractor, who is supervised by Col. John L. Inskeep. About 700 warrant officers and enlisted men will be trained there this year.

All advanced tactical aviation training is being given at the Army Aviation School, Fort Rucker, Ala. Output this year will be in the neighborhood of 2,000 officers, warrant officers and enlisted men.

Present roll of Army fliers runs to 4,700 aviators on active duty, including 800 cargo helicopter pilots.

Trio of Headaches

Aside from equipment development and the continuing wrangle over roles and missions, Army Aviation has a trio of other headaches that demand attention. Briefly, they are maintenance, officers who still think soldiers literally must keep both feet on the ground and super-salesmen.

The maintenance problem grows out of Army Aviation's ever-widening activity in an ever-widening sphere of geography. The Army has found that carrying service to the aircraft is an expensive and complicated business. The Transportation Supply & Maintenance Command, headquartered at St. Louis, is struggling with this problem and considering alternate ideas and methods of improving its efficiency.

On the second point, there is some feeling among Army aviators that senior ground officers, all of them denied an aviation training by the West Point curriculum, are inclined to resist the flying machine as something that upsets the textbooks. Gen. Howze, in fact, has made a special plea, asking these men to look upon his activity with a more tolerant and positive approach.

Finally, there is the super-salesman. No man in uniform can be very blunt about this, but from time to time a "space cadet" appears on the horizon. There were some examples of this in 1956, when the sound and sober discussion of Army's needs for tomorrow was climaxed by such "superman" concepts as a transport ballistic missile that would shoot a combat team into enemy territory.

For the time being, Army Aviation has little need for fantasy. The demands on its own people, the scientists of TRADCOM and the aviation industry are more realistic.

NATO Members Clamor for Atom Missiles, Fewer Manned Aircraft

Paris—Nuclear weapon potential to be obtained from the United States increases the possibility of a future reduction in the size of North Atlantic Treaty Organization Air Force. Planning at Supreme Allied Headquarters for 1960-62 already foresees a smaller NATO force of manned aircraft. Present clamor among European NATO members for a share of the nuclear-armed missile weapons may hasten this trend.

NATO's combat air power, remaining about the same numerically, improved in quality during 1956 with deliveries of F-100C Super Sabres to Allied Air Forces, Central Europe.

These aircraft are in service with the U. S. 12th Air Force, which makes up the bulk of the U.S. air commitment to NATO. Present strength is some ten wings, including two tactical missile squadrons equipped with Martin TM-61 Matadors. In addition to the F-100Cs, the 12th is operating F-86F and D models as well as RF-84F and F-84F types. Douglas B-66s are beginning to replace the 12th's B-57s.

Britain's contribution to NATO mainly includes the RAF's Second Tactical Air Force. The British are using Mark 5 Swift FRs along with Venoms, Mark 4 Hawker Hunters, Mark 9 and 10 Meteors and Canberras.

French Forces

French aircraft contribution to NATO still remains the Dassault Ouragan and Mystere. First SO-4050 Vautour fighter-bombers should show up this year.

Canada during the year began equipping its NATO squadrons with its Avro CF-100 all-weather fighter. One squadron arrived last November and the second this month.

German contribution to NATO airpower should make itself felt this year. GAF plans call for 1,300 aircraft covering most categories. German effort this year, however, will stress training of air crews.

CF-100 Total

This change will eventually give Canada four CF-100 squadrons in NATO. Canada's eight other NATO squadrons will continue to use the Orenda-powered Canadair F-86 Sabre fighter.

NATO's air logistic problems were somewhat eased during the year by the arrival of the U. S. 309th Troop Carrier Group. Although designed for assault type operations, the C-123 makes an excellent cargo aircraft. It is scheduled to replace C-119 units gradually.

Perhaps the most significant advance made during the year was the increased

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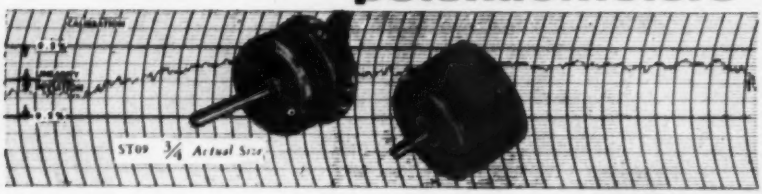

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First Report on Infrared

Infrared, the new, fast-rising competitor to radar for such applications as missile guidance, fire control, early warning and mapping, is generating tremendous interest in military-industry circles.

Aviation Week's Avionics Editor has prepared the first authoritative and comprehensive report on the applications, implications and fundamental principles of infrared.

The first article in the series, dealing with the aviation-military uses of infrared, its advantages and disadvantages, will appear in the Mar. 4 issue of Aviation Week.

emphasis on NATO's aerial defense warning system. This project now has first priority in all member countries. Gen. J. M. Chassin, former head of the French anti-aircraft system was appointed Coordinator of Air Defense, Central Europe. NATO is accelerating work on its new integrated "scatter" warning system which uses ionospheric and tropospheric forward scatter signaling.

The system, NATO claims, is almost jam-proof.

"Alert" Attitude

Sudden interest of European nations in nuclear weapon potential reflects the new "alert" attitude running through NATO.

A year ago many members debated the advisability of even having U.S. nuclear weapons in Europe. They were asking themselves how NATO's military future could be channeled into more "constructive" fields.

Soviet tactics in Hungary and the Middle East during 1956 recalled to many members the warning of Lord Ismay, NATO's retired Secretary-General, that "the Russian bear can kill with a hug."

By threatening Europe with a rain of missiles during the Suez campaign, Soviet policymakers put life into a wilting NATO.

Events in Hungary and the Middle East made it easier for NATO to patch up its split over the Anglo-French Suez campaign.

Stand Off

If the Suez affair prevented the West from exploiting the Hungary situation, the latter equally prevented the Russians from cashing in on the squabble among NATO members over the Suez canal fighting.

NATO's ministerial meeting last December, billed as the most important NATO gathering since the Lisbon

IN AIR CONDITIONING

WHEN PERFORMANCE COUNTS COUNT ON STRATOS

Turbine wheel from refrigeration unit for Boeing B-52.

Performance is the payoff in aircraft air conditioning. Weight size, efficiency and reliability are prime criteria.

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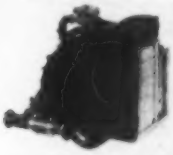
N15 Air Cycle Machine for simple system often used in fighters.



EA75 Package for Jet Bomber; Complete System includes temperature regulation, flow and pressure limitation and moisture separator.

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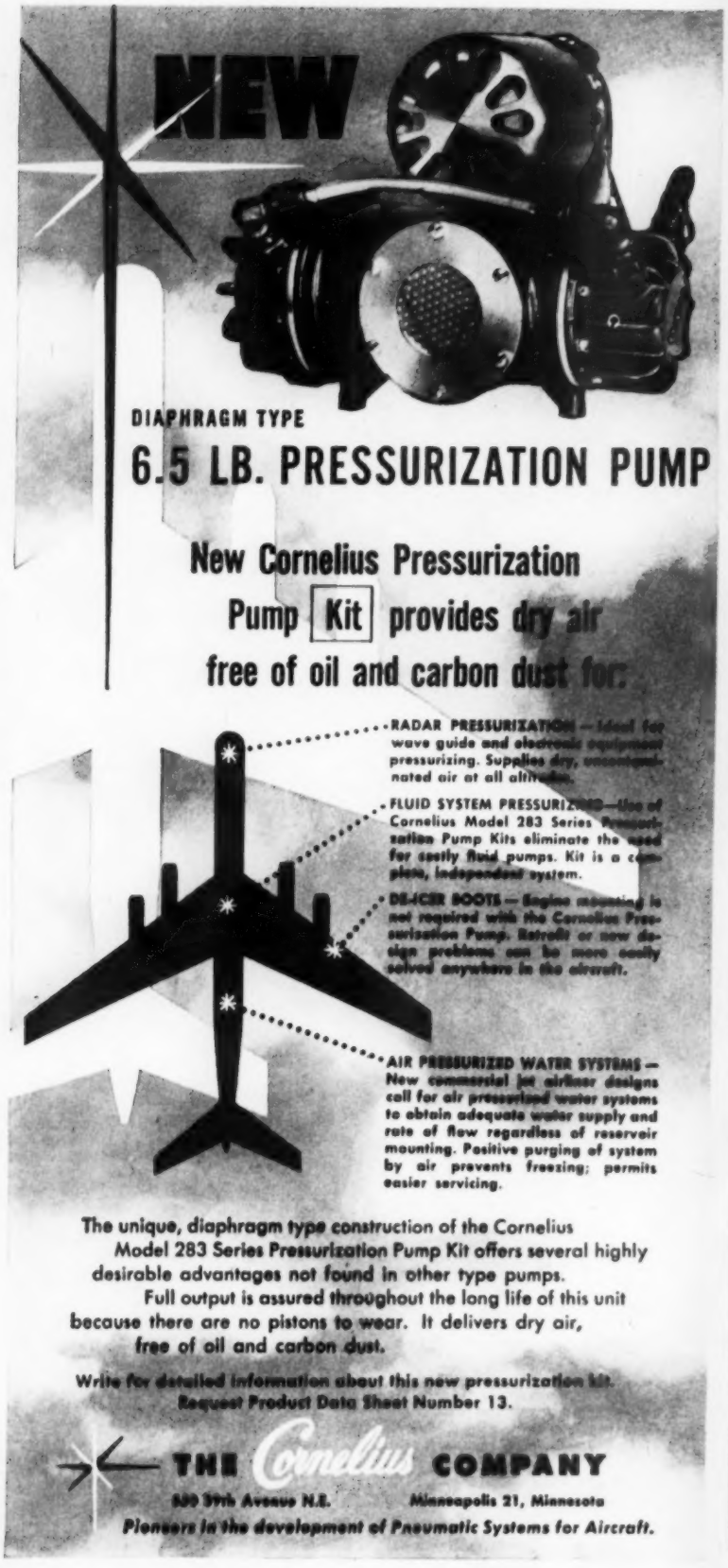
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● NATO

Conference, was only the beginning of a reappraisal of NATO defense needs which is still going on. U.S. Defense Secretary Wilson clearly implied that under the military assistance program the U.S. would make available certain missiles together with appropriate technical data. The weapons, it was understood, would be dual-purpose, capable of firing conventional or atomic warheads.

Out of this offer came the current interest in U.S. missiles by NATO members, notably Great Britain, to fill the arsenal.

Norstad Strategy

NATO's new Supreme Commander of the Allied Forces in Europe, General Norstad, who replaced General Alfred M. Gruenther, is an old NATO hand.

So is Belgian's Henri Spaak who, when accepting the top staff post of secretary-general from Great Britain's Lord Ismay, remarked that since his wedding he had not said "yes" in such momentous circumstances.

Neither appointment will greatly alter NATO future policy, but Spaak can be expected to pay more attention to NATO's unifying effects on the European scene.

Norstad doesn't intend to drop the "forward strategy" concept in favor of the so-called "trip-wire" defense thinking.

By this the General means he intends to demand the full 30 division NATO goal which was determined in Lisbon in 1952.

To settle for anything less, he argues, would favor "trip-wire" strategy under which the Russians would be tempted to wander over the "line," settle in, and then wait while NATO decides what to do.

Russian Blame

Under forward strategy, the Russians know if they cross the line they will have a war on their hands.

Thus, present strategy contains a strong deterrent element, and saddles the Russians with the responsibility if a war should happen to break out in Central Europe.

During the coming year General Norstad may run into a stiff battle not only to retain his 30-division goal but to hold on to what he already has. Now that European member nations more or less accept the idea of increased quantities of nuclear weapons on the continent, they may go too far in basing their defense on such weapons.

This would take the strain off many a European defense budget and result in a reduction in NATO ground and air forces in Central Europe, but it would also necessarily place additional responsibility on USAF's Strategic Air Command.

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In the fields of both *AERO*-NAUTICS and *ASTRO*-NAUTICS Convair is showing outstanding leadership. **CONVAIR-*Astronautics*** is today building in San Diego, California, a complete facility for research, development and manufacturing of the Atlas Intercontinental Ballistic Missile, a top priority project of the U.S. Air Force. The Atlas is the first of many vital astronautical projects which will lead mankind toward a better understanding of the universe in which he lives.

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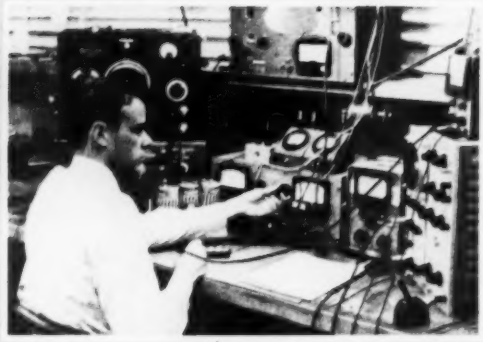

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Communications activities at The Ramo-Wooldridge Corporation include research, development, and manufacture of advanced types of radio communication systems, ground-reference navigation systems, and electronic countermeasure systems. Major programs are in progress in each of these fields.

New and unusual techniques have been employed to provide systems having a high order of security in the transmission of information, broad flexibility in combating unfavorable signal propagation conditions, and substantially greater information capacity per operating channel.

Some of the techniques used have made possible an increased range for given levels of transmitter power and reliability of communications. Others have provided specific advantages in very long distance communications or in operational situations requiring unique signaling capabilities. Developments in navigation systems have resulted in new equipment that is suitable for the guidance of aircraft at long ranges from their bases.

In the work currently under way, some systems are in the laboratory development stage, some in the flight test stage, some are in production. Several types of systems developed and manufactured by Ramo-Wooldridge are in extensive operational use.

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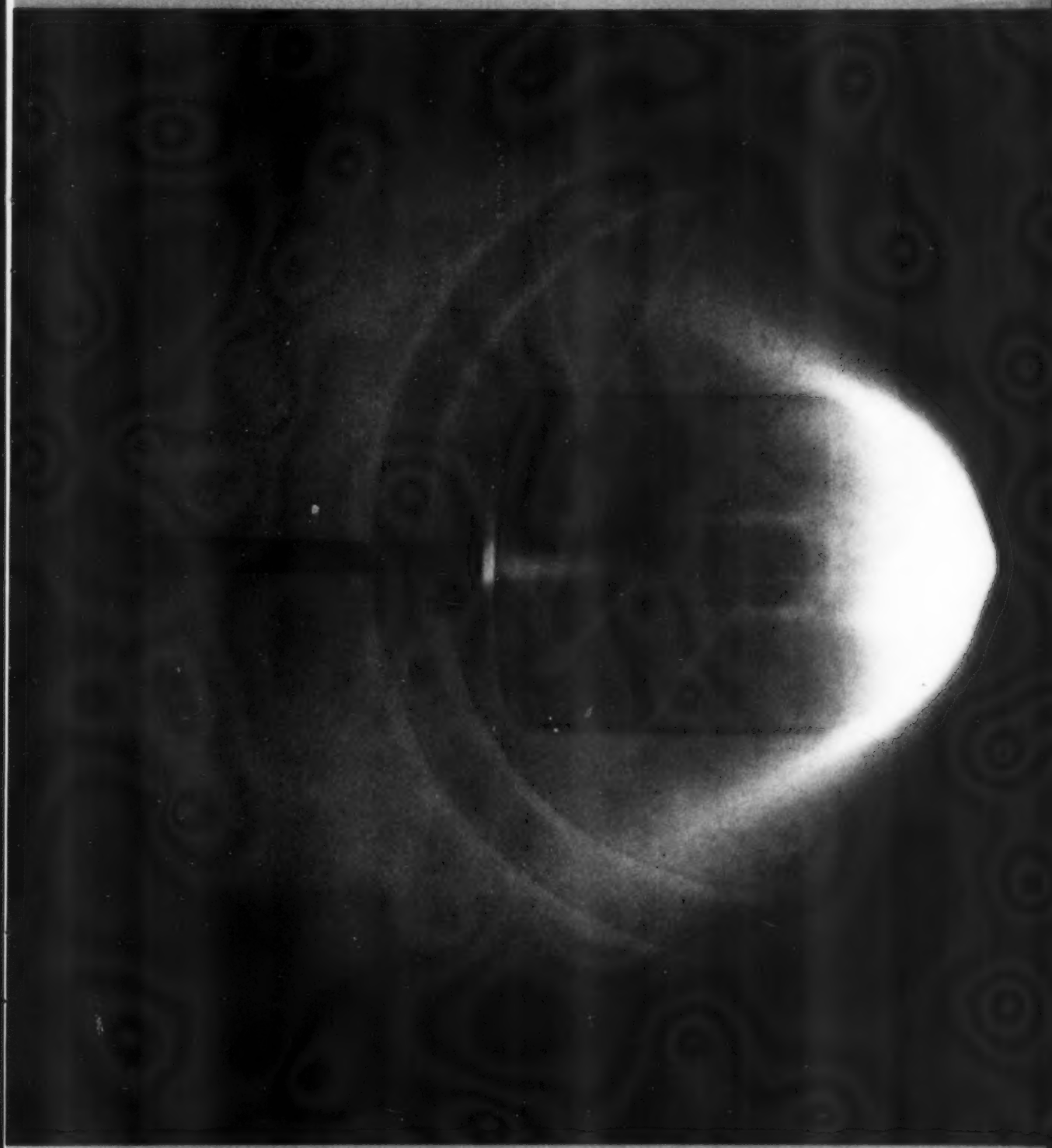
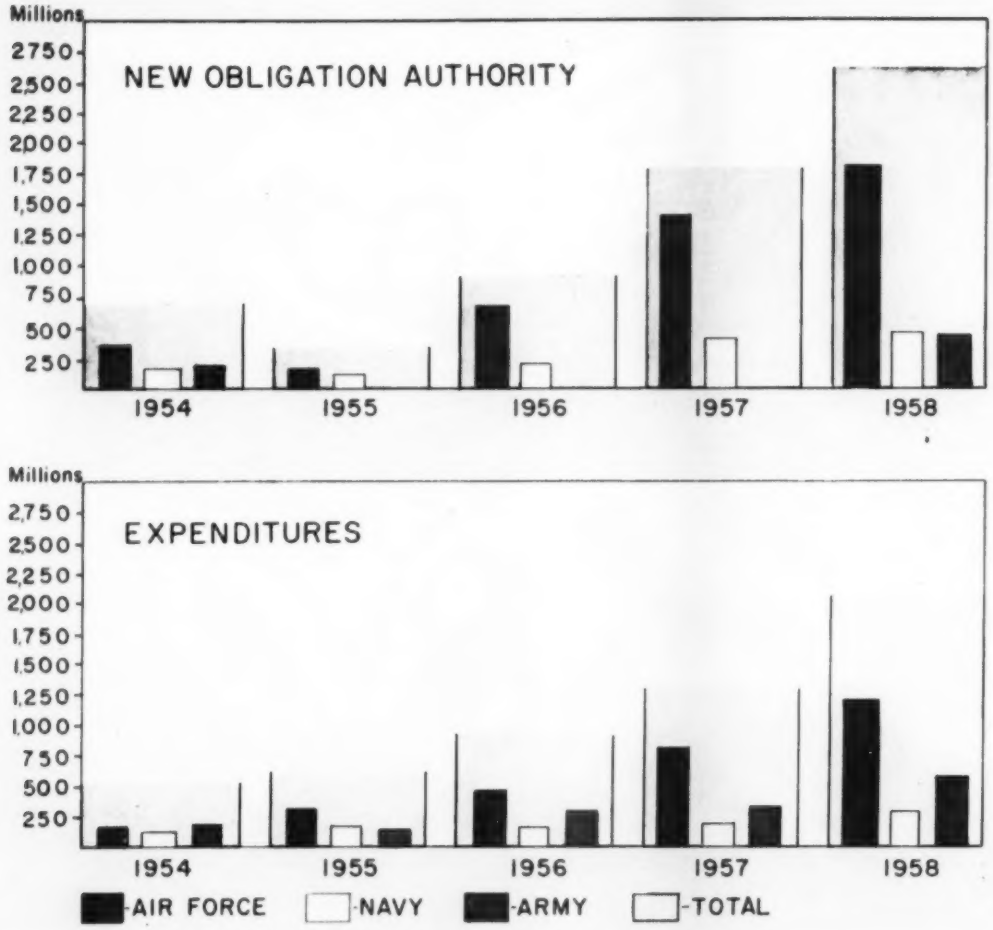


Incandescent model, blunted like ICBM nose, burns in Cornell Aeronautical Laboratory shock tunnel.



Services Push Missile Programs Hard

By David A. Anderton

Five ballistic missiles dominate the current U.S. weapons scene.

Now bearing a super-priority rating for procurement, these five—Atlas, Jupiter, Polaris, Thor and Titan—outrank all lesser missiles in their claims on technical manpower, test range time, facilities and missile dollars.

These projects are loosely organized into an over-all program that compares in scope and urgency with the Manhattan Project that produced the first atomic bomb during frantic months of World War II. But there the resemblance ends.

The Manhattan Project was a single entity organized to achieve a single goal.

The ballistic missiles program consists of three entities organized to race the Russians to a pair of goals: the achievement of 1,500 and 5,000 mi. range intercontinental missiles.

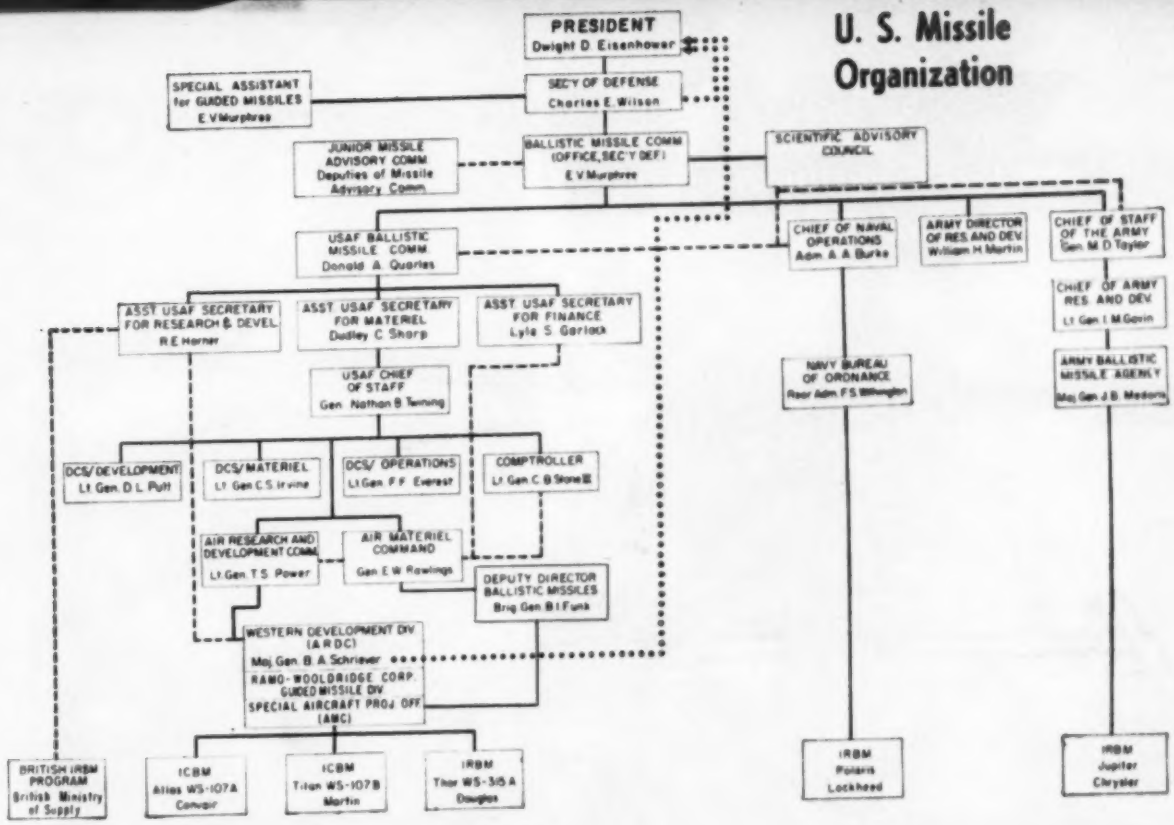
But besides racing the Russians, each of the U. S. missile projects is busy racing the others. It has become a matter of great face to get the first long range missile off the firing stand and into the air. Each of three military services is eager to come up with the ultimate weapon and to be hailed as the savior of the country.

Part of the main race already has been lost. The Russians have been firing a ballistic missile of approximately 1,000-mi. range with amazing frequency and regularity over the past eighteen months (AW Feb. 20, 1956, p. 26). This development has made more than one technical observer question the wisdom of continuing with a 1,500-mi. missile program when the Russians are obviously so near to that goal.

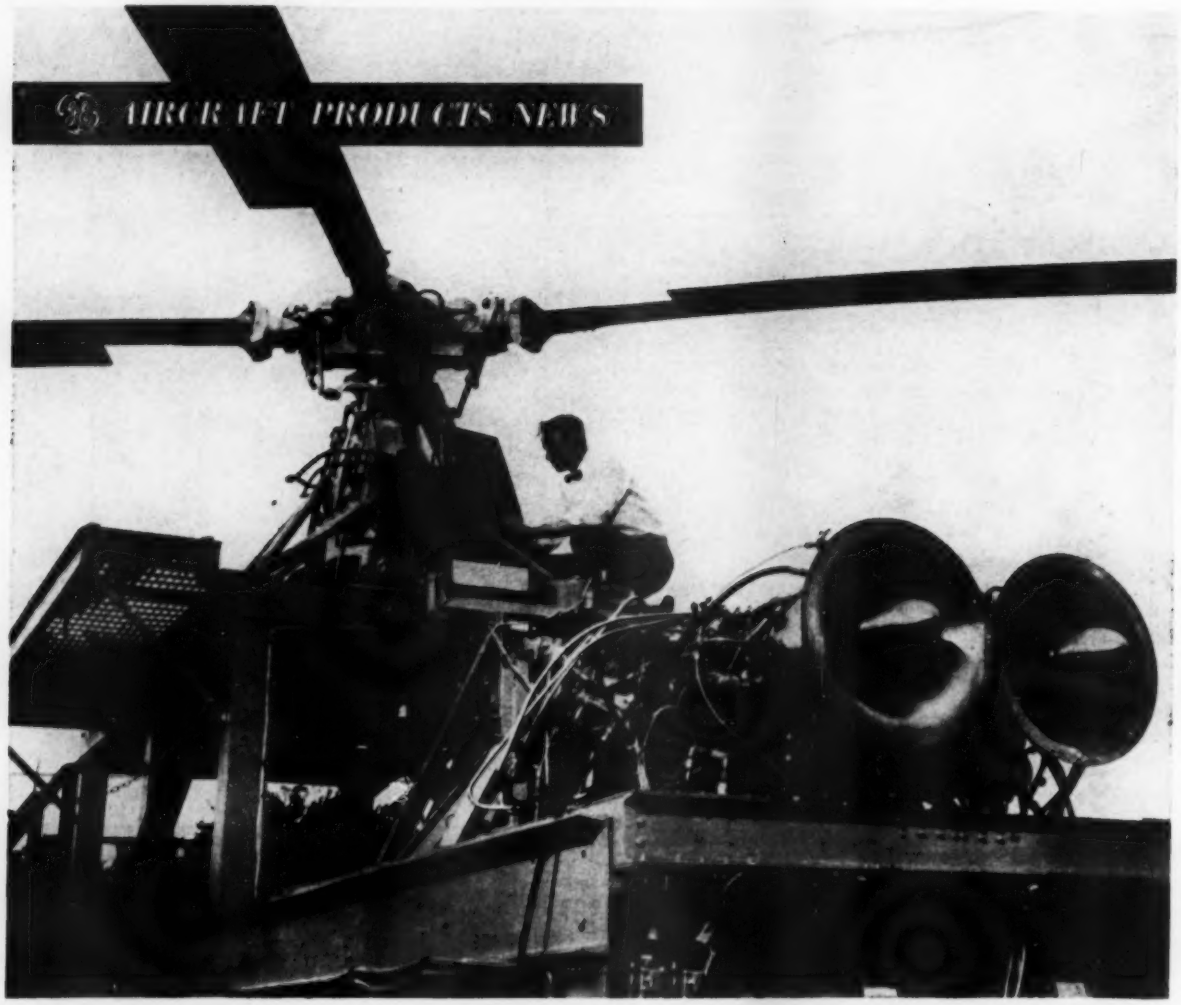
These Russian firings, coupled with a technical breakthrough in reducing the size and weight of thermonuclear warheads, provided the political and technical impetus to accelerate the ballistic missile program in November 1955.

At that time, there were two projects in the works. The Air Force had Atlas, with Convair Division of General Dynamics as the prime contractor. The Army was developing the Redstone missile at the Redstone

U. S. Missile Organization



NORTH AMERICAN X-10



General Electric's T58 engine, featuring free power turbine controlled through new constant-speed control, undergoes system tests.

Tests Show How T58 Simplifies Control, Promotes Operating Efficiency of Helicopters

Designed to take full advantage of the General Electric T58 turboshaft engine's free power turbine, the new G-E constant-speed control permits operation of a helicopter rotor at maximum levels of efficiency and eliminates the need for speed adjustment by the pilot during normal operation. A new concept, this hydro-mechanical control is designed to maintain essentially constant rotor speed by automatically regulating engine power. The new control will permit helicopters to more effectively use the turboshaft engine's 3:1 power-to-weight ratio and 0.69 normal SFC to more than double their present ton mile capacity, fly at much faster speed, and reach a new level of operating economy.

Specific advantages of the new control are being demonstrated at General Electric's Flight Test Center, Schenectady, N. Y. In these tests a complete T58 power system including reduction gear, constant-speed control, and transmission and rotor for the Sikorsky S-58 helicopter are being operated over a wide range of rotor speeds and power settings. These five distinct advances in helicopter operation are provided by T58's advanced design constant-speed control:

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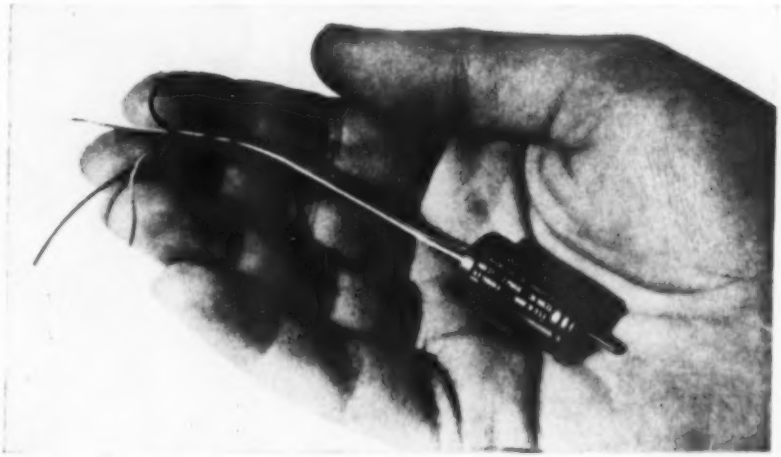
5. FULL POWER UTILIZATION of both engines without danger of engine or rotor overspeeding.

For more information on the constant-speed control and the many other advanced features of the General Electric T58 engine, contact your G-E Apparatus Sales Office. Check block A on the coupon at right for your free copy of the T58 descriptive brochure.

New, Thumb-size 400-Cycle Servo Motor to Help Increase Accuracy of Measurement and Control

The new General Electric, 400-cycle servo motor weighs only 1.2 ounces yet provides the high accuracy needed in null-method measurements and power to initiate control. This exceptionally small motor (5/8 inches in diameter by 1.2 inches in length) has the high torque-to-inertia ratio to qualify for many applications. The two-phase principle fits it for use in a wide variety of circuits used to convert error signals from a synchro-control transformer into control action. Other uses include power-failure indicating and power-brake applications.

To achieve accurate operation the motor is designed around a two-phase stator. The first phase is excited by a fixed potential, the other, the variable phase, is excited only when torque or rotation is desired. Motor torque or speed is controlled by varying the input to the variable phase and the direction of rotation is controlled by the relative phase angle (lead or lag 90 degrees) between the inputs to the fixed and variable phases. In this way the motor can be controlled so as to operate under continuously stalled conditions through to a no-load speed minimum of 19,250 RPM.



New General Electric servo motor has high torque-to-inertia ratio and can operate under continuously stalled conditions through to a no-load speed minimum of 19,250 RPM.

Watts per phase at stall is 3.4, at no load 2.00.

Sturdy construction gives the new servo motor capabilities to withstand extremes of environment. It will operate satisfactorily at altitudes up to 60,000 feet and at temperatures from −55 to +90 C. The motor is rated at 26 volts and has exceptionally high acceleration, stall torque, and efficiency for a motor of its size and type.

For more information on this new 400-cycle servo motor check block B on the coupon below or contact your nearest G-E Apparatus Sales Office.

New Molded PVZ* Tubular Capacitors Meet 125 C Requirements at Half the Cost of Metal-Clads

Priced at less than one-half the cost of a comparable metal-clad tubular, the new G-E Molded PVZ Tubular Capacitor meets requirements for a quality capacitor at a moderate price. Designed for advanced electronic equipment, the new capacitor line has characteristics similar to "K" of MIL-C-25A and will operate at temperatures from −55 C to +125 C. Life is a minimum of one year at rated voltage and 125 C.

Excellent humidity characteristics are assured through the use of high-grade case material and carefully controlled molding techniques. Though small, to aid equipment miniaturization, the insulated bodies are easy to locate in the chassis and provide protection from other parts or ground. Lead pull and bend resistance is high.

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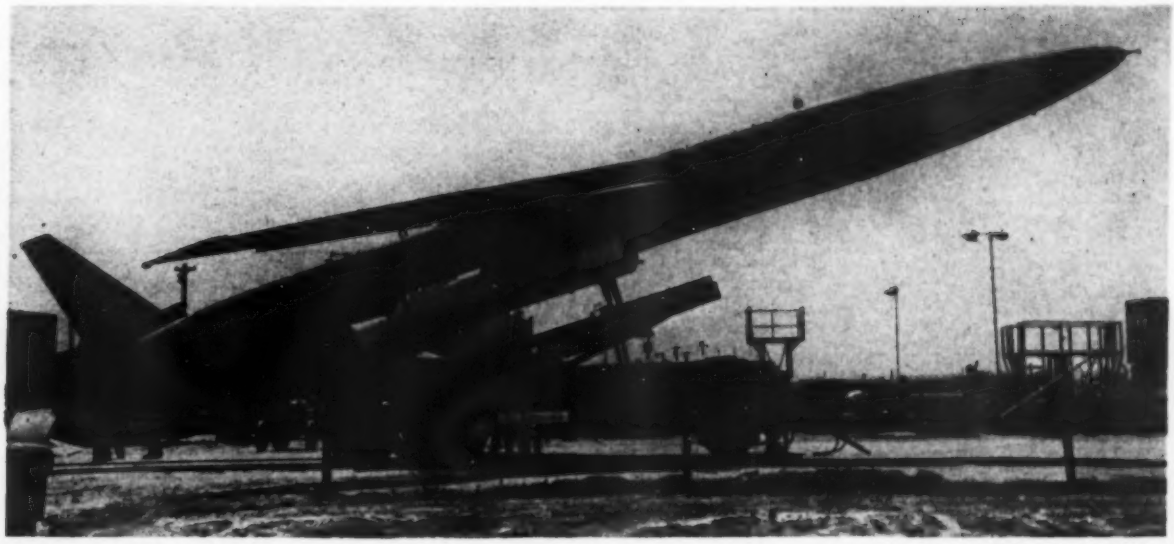


NORTHROP SM-62 SNARK

Arsenal as a preliminary vehicle for an IRBM.

Acceleration of the ballistic missile program was to take two forms. First was the appointment of a missile czar, a single person with overall authority to observe the programs and to make any changes consistent with stepping up the pace.

Backup Projects

Second—paradoxically, it seemed to some observers—was to attempt to hasten the development by adding backup projects.

The Air Force added a second ICBM, the Titan, to be monitored and developed under the Martin Co., and a brand-new intermediate range missile, the Douglas Thor. The Navy got into the act by joining forces with the Army in what was to become an unholy alliance, with neither side ever fully accepting the other service's point of view.

The missile czar's job—officially that of Special Assistant to the Secretary of Defense—went to Eger V. Murphree. His first examination of the missile program he had been called in to overhaul and monitor revealed no cause for alarm, he said. He expressed satisfaction with the existing state of affairs.

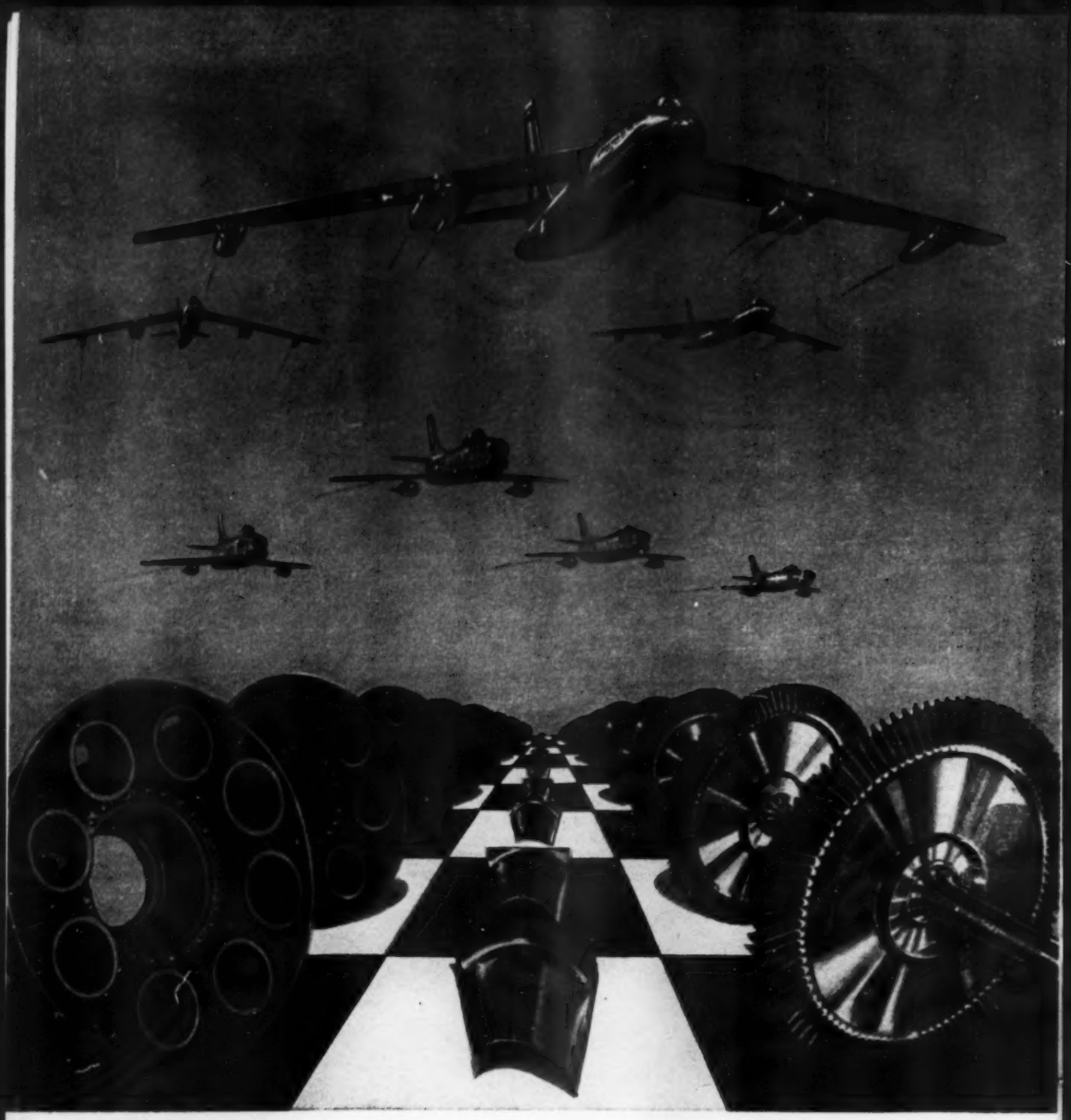
Murphree's action in the job was 180 degrees removed from that of his predecessor, K. T. Keller. By knocking heads together in a process which gave a new word—Kellerizing—to the technical vocabulary, Keller brought a fresh approach to the missile program during the early phases of the Korean conflict. Most of the missiles in production and operational use today are available because Keller insisted on freezing their designs and putting them into production.

Fleet Missile

Latest long-range missile project is Navy's Polaris, to be developed by Lockheed's Missile Division. Navy pulled out of the joint Jupiter program, saying that its requirements for a fleet ballistic missile were such that they could not be met by the Army's proposed Jupiter configuration.

To these five long-range projects must

MARTIN TM-61B MATADOR



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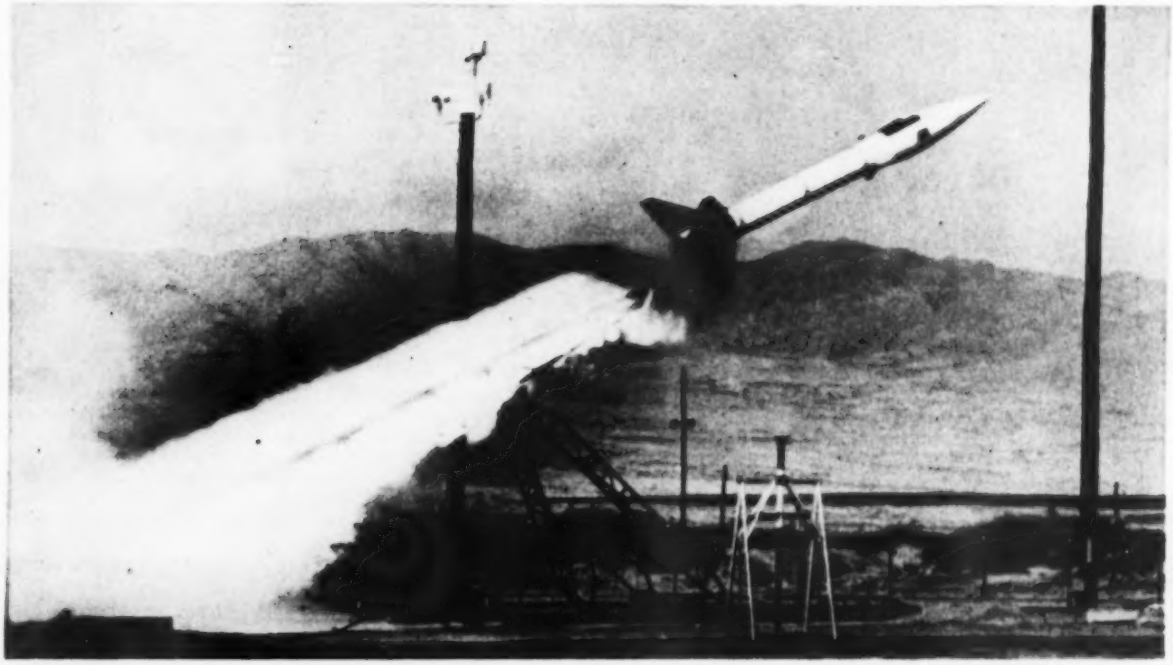

DOUGLAS HONEST JOHN

be added a sixth—the British intermediate-range ballistic missile which has been monitored by the Assistant USAF Secretary for Research and Development.

Advances and Setbacks

Much technical progress and one or two minor technical setbacks have been recorded in the five programs during the past year:

• **Army fired** a "test device" for the Jupiter program which traveled the better part of 3,000 mi. The three-stage assembly was made up of a Redstone thrust unit as first stage, with a cluster of Sergeant solid-propellant rockets as a second stage and a single Sergeant as a third stage.

• **The first launching** of the Douglas Thor ended in disaster when the missile climbed to an estimated 200 ft. above the ground and flashed into flames which completely destroyed the giant rocket.

The trouble was traced to failure of a small component, which is a comfort, although a hollow one, to the designers of the complete system.

• **Static test firings** of the huge North American liquid-propellant engines which will power the Convair Atlas were accomplished.

• **New Approaches** to the design of nose cones to enable them to withstand the terrific thermal loads and thermal shock during re-entry solved some of the problems of getting the warhead to earth intact. One of the more success-

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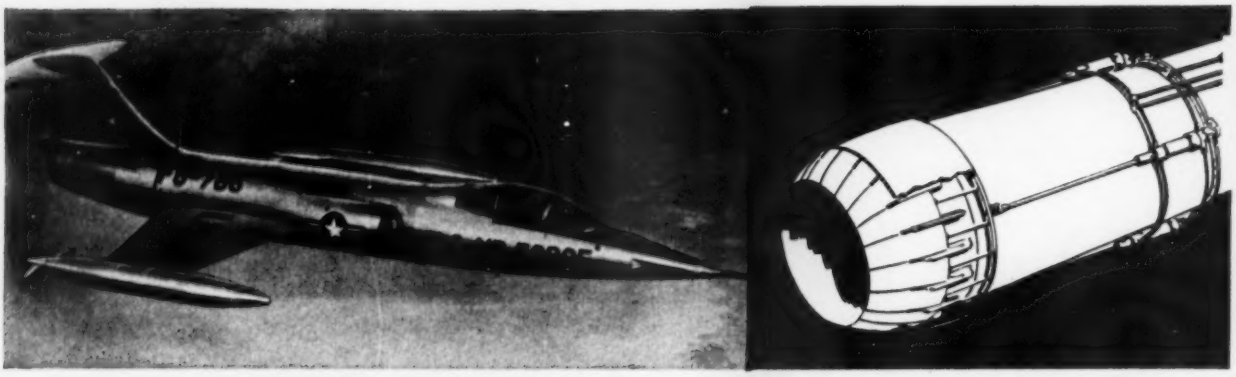
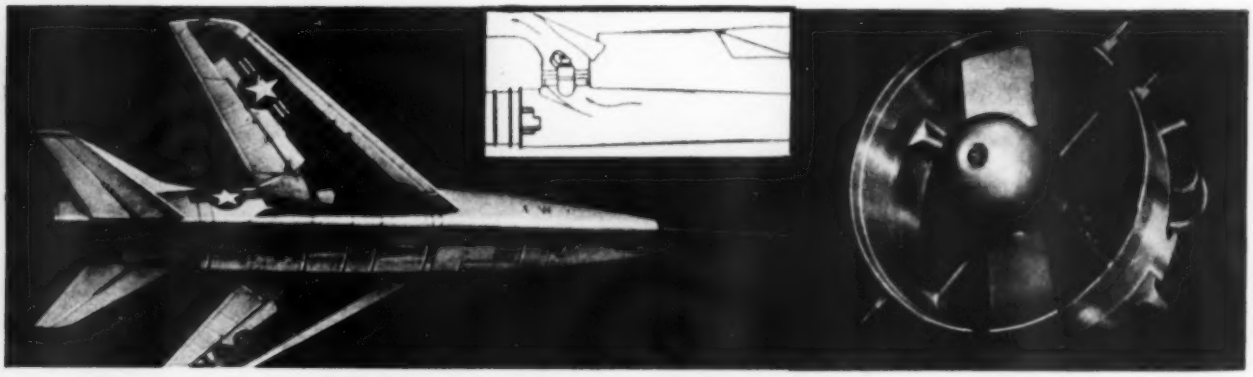


AFTERBURNER ACTUATORS – *the Lockheed F-104A Starfighter,* world's fastest fighter plane, has four Aeroproducts actuators on the afterburner for orifice control of its J79 engine. Designed for extremely high temperature operation, these hydraulic actuators are synchronized to co-ordinate in perfect unison, providing instant, positive control of the afterburner nozzles. This patented feature of mechanical synchronization provides precision positioning by incorporating flexible shafting within the hydraulic tubing to co-ordinate the linear travel of the actuator pistons. Another safety factor is a stroke limiter which prevents the tail cone from closing completely in the event of hydraulic failure.

WING INCIDENCE ACTUATORS – *the Chance Vought F8U-1 Crusader,* world's fastest Navy fighter plane, showing its unique two-position incidence wing in "up" position for take-off. Inset shows normal flight position. First operational plane to incorporate this principle, the F8U-1 has an Aeroproducts self-locking hydraulic actuator which controls the angle of attack of the wing. Changing the wing angle permits the Crusader to land level with the runway of the carrier deck, giving the pilot better visibility and permitting use of shorter, lighter landing gear.

RAM AIR-DRIVEN GENERATORS – *in the Douglas A4D Skyhawk* – Aeroproducts emergency air-driven generator is first production application of ram air-driven equipment. Suspended beneath the fuselage, this lightweight unit (22 lbs.) gets up to speed in less than 1/10th second and develops 1.7 KVA @12,000 R.P.M. to operate radio, lights, instruments, trim tab and elevators. It has successfully performed in emergencies and has been dropped out many times on flight tests. Using a simple blade pitch changing mechanism, the unit governs its output frequency within plus 10% and minus 5% over a very wide range of airspeed, altitude and load conditions. This unit also has application in tow targets to generate power for scoring mechanisms.



AIR-DRIVEN HYDRAULIC PUMP – *the North American F-100D Super Sabre* is equipped with an Aeroproducts air-driven hydraulic pump which produces sufficient hydraulic pressure for flight controls in case of either engine or hydraulic failure. This lightweight ram air pump is mounted back of the cockpit, where air from engine air inlet ducts can be directed by the pilot to drive the turbine-pump in emergencies.

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ENGINEERS AND BUILDERS OF OIL HYDRAULIC EQUIPMENT SINCE 1921

ful tests has resulted in a nose cone of Fibreglas and ceramic design.

• **New facilities** have given the designer data never before available. To the rapidly increasing mass of aerodynamic test points for Mach numbers up to six has been added a wealth of data at hypersonic Mach numbers and at very low pressures made available by shock tubes, shock tunnels and molecular beam tunnels.

Expansion of the number of these facilities moved ahead noticeably last year to provide the missile designer with this additional data.

Snark and Navaho

Competing with these ballistic missiles for attention are two air-breathing cruise-type weapons, the Northrop Snark and the North American Navaho.

Snark is a subsonic, turbojet-powered missile about the size of a medium bomber, yet having a range potential of 5,000 mi. carrying a thermonuclear or nuclear warhead.

Production has been authorized after several years of vacillation, and the first SM-62 Snark pilotless bombers are expected to become operational with units of Strategic Air Command within one year.

Navaho is a supersonic, ramjet-powered missile with a somewhat shorter range capability than that of Snark.

Designated SM-64, the Navaho is in a development status.

Flight testing of the X-10, a guidance and aerodynamic test vehicle for Navaho, has been completed and the work with the final test configuration has begun.

Navaho is a delta-winged tailless configuration with large dihedral in the surfaces to provide stability around the roll and yaw axes.

The X-10 has a canard configuration which was discarded in the Navaho. Two Westinghouse J40 turbojets powered the X-10; Navaho has two wing root mounted ramjets.

Not Interim Weapons

There is a tendency to regard both Snark and Navaho as interim weapons; this is not correct. They were developed with specific requirements in mind and, at the time, seemed to be the only answer to intercontinental warfare with pilotless aircraft.

In their early days, these two—plus some other, since-dead projects—appeared to be the only way to transport a large and bulky atomic warhead over vast distances.

The size of those missiles was almost entirely governed by the size of the charge, which was then of formidable proportions. To attempt to incorporate a warhead weighing several thousand

ROCKET POWER PROGRESS REPORT

Taming Rocket Powerplants

by Walter O. Borcherdt

In charge of the Engineering Development Laboratory as well as the Valves and Controls Section at RMI, Mr. Borcherdt has over a decade of rocket experience. Before coming to RMI in 1951, he was senior project engineer on controls in the rocket department of Curtiss-Wright Corporation. Mr. Borcherdt received his degree in mechanical engineering from Stevens Institute of Technology in 1938.

Reliability of a rocket powerplant is the direct result of the simultaneously correct operation of all of its elements. Generally, this is assured by overcoming each element's own peculiar development problems. Among these elements is one type which has the interesting property of being composed of specific components, yet whose operational characteristics are significant only in the performance of the entire powerplant system. This element is the control system.

Present powerplant controls requirements are based on these straightforward, simple considerations:

1. Prepare the powerplant for firing
2. Sequence and control the system to rated thrust
3. Vary thrust rapidly and safely as required
4. Shut down smoothly

Step one may require the use of gas pressure regulators and relief valves to push the propellants safely from tankage to pumps. There must be switches and relays to indicate or control the valves which admit propellants to the gas generators and combustion chambers, and time delay cutouts to insure against unsafe accumulation of propellants.

In step two, ignition and combustion may be monitored to insure correct use of the high energy release rates. Turbines may be safely brought up to speed by throttling the propellants. Safety devices may be added to limit over-speed and avoid the danger of structural failure.

In step three, a controller (it may be hydraulic, electric, pneumatic, or a combination) is used to vary thrust. Here multiple loop servo systems are sometimes used to insure that thrust change rates, turbine speeds, vehicle acceleration or terminal velocity, and other parameters vary in a coordinated manner.

Finally, in multiple stage powerplants or piloted vehicles, the rocket engine must be shut down safely and the system automatically purged of propellant accumulations.

The successful implementation of these four steps involves the application of many devices of unique characteristics whose individual selection is intimately tied to the following question:

"What is the actual control system problem to be solved?"

Once this question is clearly and consistently defined, a tight performance envelope results. This makes the few possible solutions fairly obvious. The final stage is to apply the knowledge of a team of control specialists and proceed through the usual component development stages. At RMI, this team of specialists in controls engineering is made up of highly qualified mechanical, electrical and chemical engineers. These professional men have wide experience in the creation of control units and systems for rocket powerplants as well as other types of propulsion systems. However, there is a continuing need for qualified graduate engineers, able to participate in working closely with other groups of specialists, integrating the control system into the overall engine performance envelope.

The systems approach is of extreme importance to successful rocket powerplant control efforts. It is a standard approach of the RMI Controls Section. Sequence system design, switching circuit analysis, human engineering, feedback control methods, statistical procedures, information theory and latest research data on fluid flow control are among the techniques used. They are applied along with practical design concepts which result in the development of simple but effective controls systems.

If you desire one or more reprints of Mr. Borcherdt's article, or would like to receive further information about employment at RMI, write to our Information Services Coordinator, Reaction Motors, Inc., 14 Ford Road, Denville, New Jersey.

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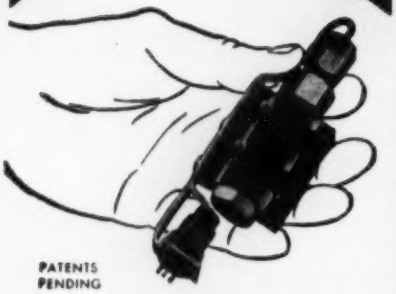
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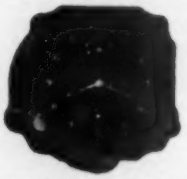
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pounds into a multi-stage rocket-powered missile would have resulted in a three- or four-stage monster looking like the Empire State Building and weighing in at a gross approximating the S.S. Queen Mary's.

Consequently rockets were shelved until the technical break-through which reduced the size of the nuclear package to a reasonable dimension.

Delusion of Cheapness

All of these missiles, whether rocket powered or air-breathers, brought with them a new complexity. The first reaction to missiles centered around their original concepts as cheap, expendable, one-shot items that could be thrown away in quantity without wrecking the economy of a nation.

Part of this concept stemmed from German data on production of the V-2 rocket. In quantity, this weapon was built for a little over 8,000 man-hours per unit.

They were exceptionally cheap man-hours, at that, lacking the high overhead that today's benefits have brought. The weapon itself was built of the cheapest materials, largely of the German equivalent of cold-rolled steel. Quality materials were used, of course, and where it counted. But the idea of a cheap weapon had taken root.

During successive years, the missile engineer has seen the cost of his expendable design mount until it now compares favorably with that of the airplane it is intended to supplement. There have been reviews of the missile program in which concern was expressed—in a mild way—over the cost spiral which was posing a problem in production.

Technical Criterion

But the missiles that were dropped out of the overall program at the time of review were eliminated because of the lack of technical progress rather than the high cost.

Official recognition of the high cost of missile living broke through belatedly.

Last month, in speeches to the annual meeting of the Institute of the Aeronautical Sciences, three of the service's top missile men and the chief scientist of the Air Force warned against the tremendous price rise in today's weapons.

Bluntest of the comments was made by Rear Adm. John E. Clark, Director of Guided Missiles in the Office of the Chief of Naval Operations. Adm. Clark said that missile programs have failed completely in the area of dollar cost. Unit costs have risen even after the missiles have been placed in mass production, and this has never happened before.

Part of the blame, Clark said, was

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The Talco Rocket-Catapult*, having the same mounting provisions, can be readily installed in all aircraft equipped with conventional catapults. Variations of this basic, proprietary design are being completed for many advanced aircraft.

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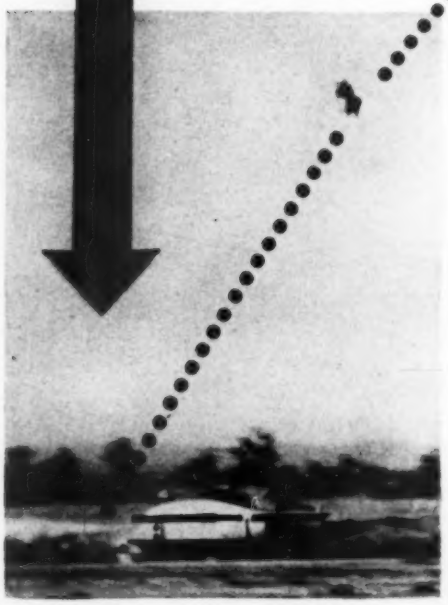
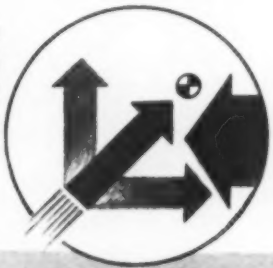


In sled tests at .73 Mach, conducted at Edwards Air Force Base, the Talco Rocket Catapult* carried a man-seat mass to approximately 60 feet in a stabilized trajectory for a normal parachute deployment and landing. In other ground level tests at zero velocity the man-seat mass was ejected to a height of approximately 220 feet, again, with full parachute deployment and a normal landing.

After the catapult tubes separate, the rocket contained in the inner tube provides a continuing thrust through the center of gravity of the man-seat mass, providing forward thrust to counter air drag and upward thrust to insure aircraft clearance at high speeds and sufficient ejection height for a complete "on the deck" escape capability.



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the military's outdated specifications and standards, delays in decisions, insistence on changes conspired to increase the cost. But an equal share was the contractor's responsibility, Clark added, suggesting that the contractor might try to look on missiles as if they had to be manufactured and sold competitively.

High Cost

But one outburst does not make a change, and observers will be keenly interested in seeing whether or not the opposition to high cost continues or quiets down.

This is a matter for serious concern, because even as simple and unsophisticated a weapon as the Navy's Sidewinder air-to-air missile costs approximately its own weight in silver. And Sidewinder is an order of magnitude cheaper than its counterparts.

The cost of a sustained offensive using missiles wouldn't be believed even if it could be calculated. But then neither would the cost of a conventional-weapon drive.

But more than cost was bothering some missile men. The Vanguard project, scheduled to attempt a satellite during the International Geophysical Year starting in July, helped to shift attention from the sordid aspects of intercontinental warfare to the skies and the mysteries of an unexplored universe.

As the deadline nears, and test rounds have been fired, the talk has changed from early beliefs in success to current descriptions of the firings as "six earnest tries." There has been some talk that the "pure" scientists were too easily assured that a satellite was feasible now, and that after the high-level decisions were made in committee, the problem was thrown into the laps of the engineers to "fill in the details."

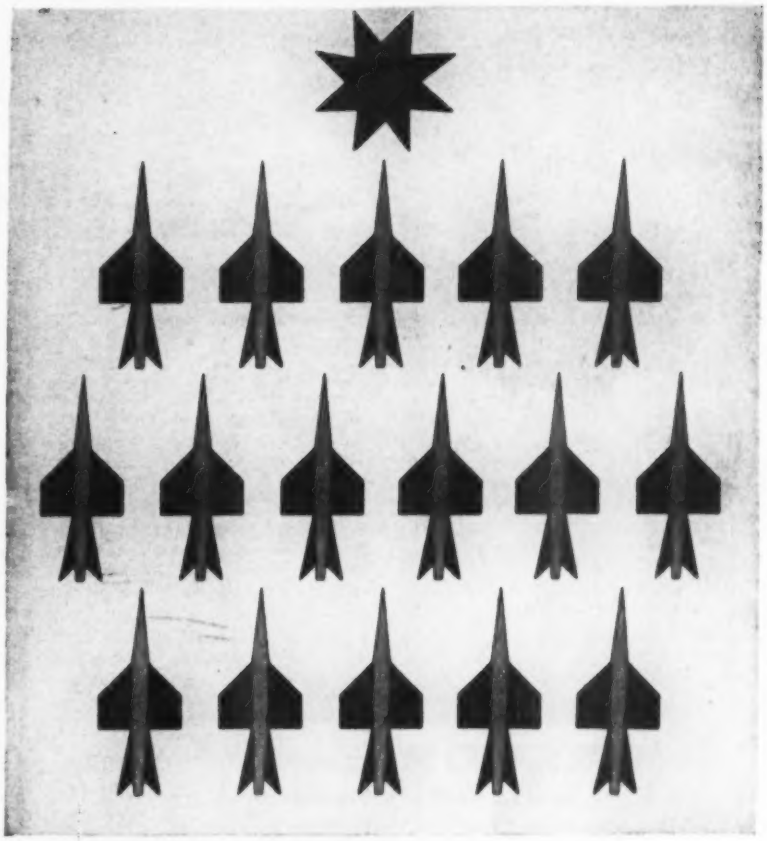
Vast Gap

In point of fact, a satellite vehicle and an intercontinental missile are relatively easy to design in a crude manner.

Science-fiction writers have been doing it—and now loudly claim so—for years. Only the details needed to be supplied by the engineers, they have proclaimed.

These details make or break any project. There is a vast gap between concept and execution, and it cannot be filled by science-fiction. It has to be bridged by long and sweaty hours of mental and physical labor, by the heartbreak of failure and the glow of success, by the flow of the necessary money to buy bits and pieces and time and engineers.

The gratifying part is that, so far,



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Auxiliary Power Scroll and Nozzle Assembly

ABOVE: Completed Power Scroll.
LEFT: Cross-Section showing intricate fabrication details.

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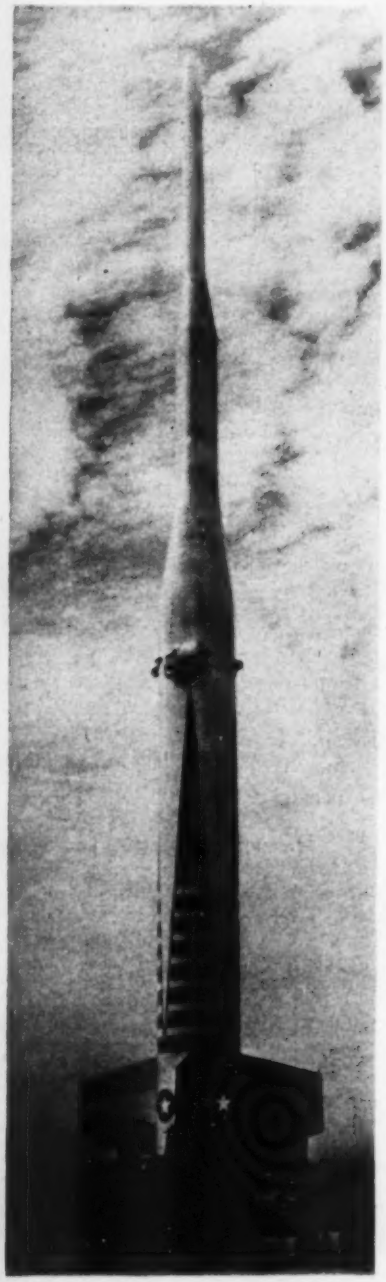
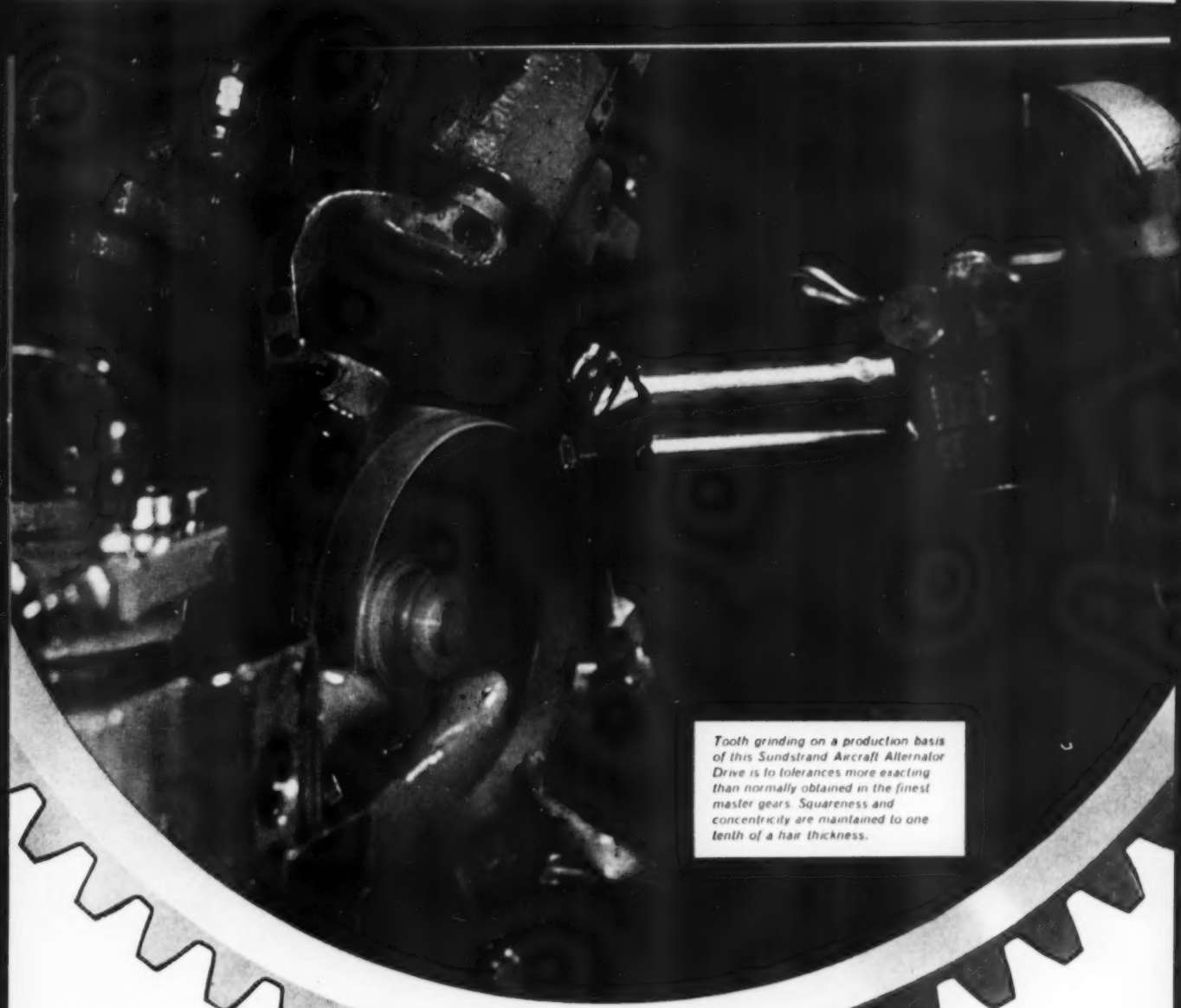
What remains is the proof of the overall systems.

This is the big promise for missile development in 1957.



LOCKHEED X-17



Tooth grinding on a production basis of this Sundstrand Aircraft Alternator Drive is to tolerances more exacting than normally obtained in the finest master gears. Squareness and concentricity are maintained to one tenth of a hair thickness.

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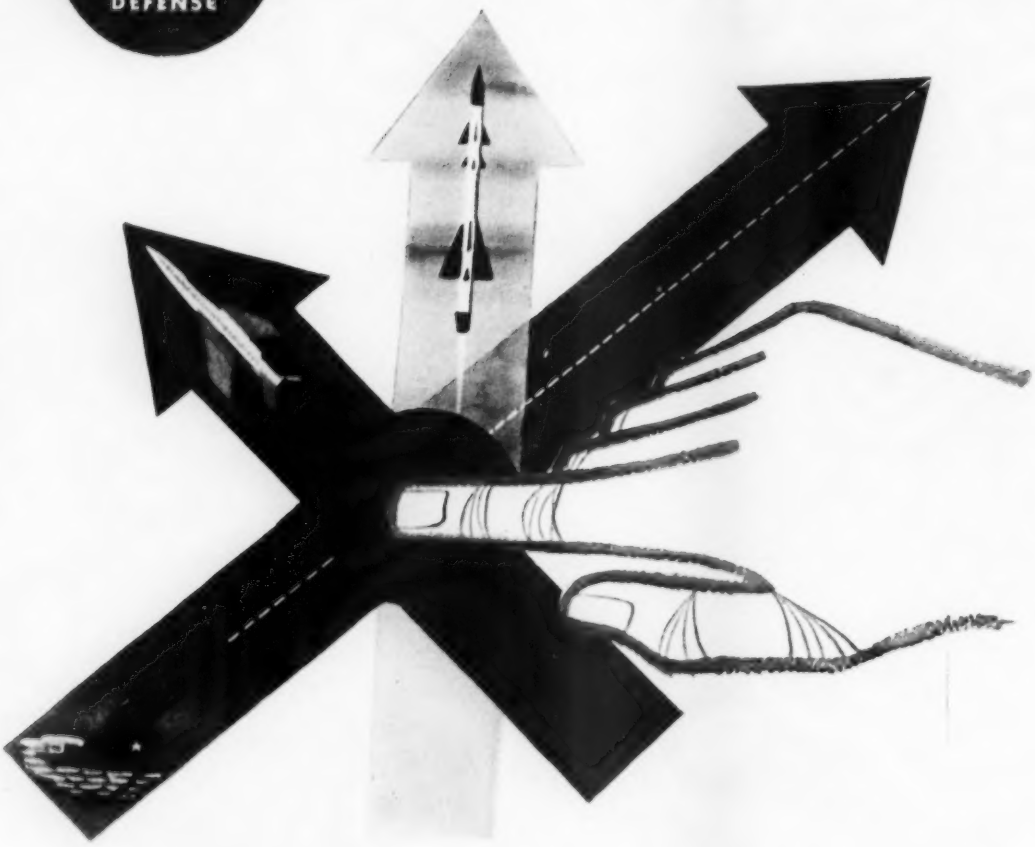

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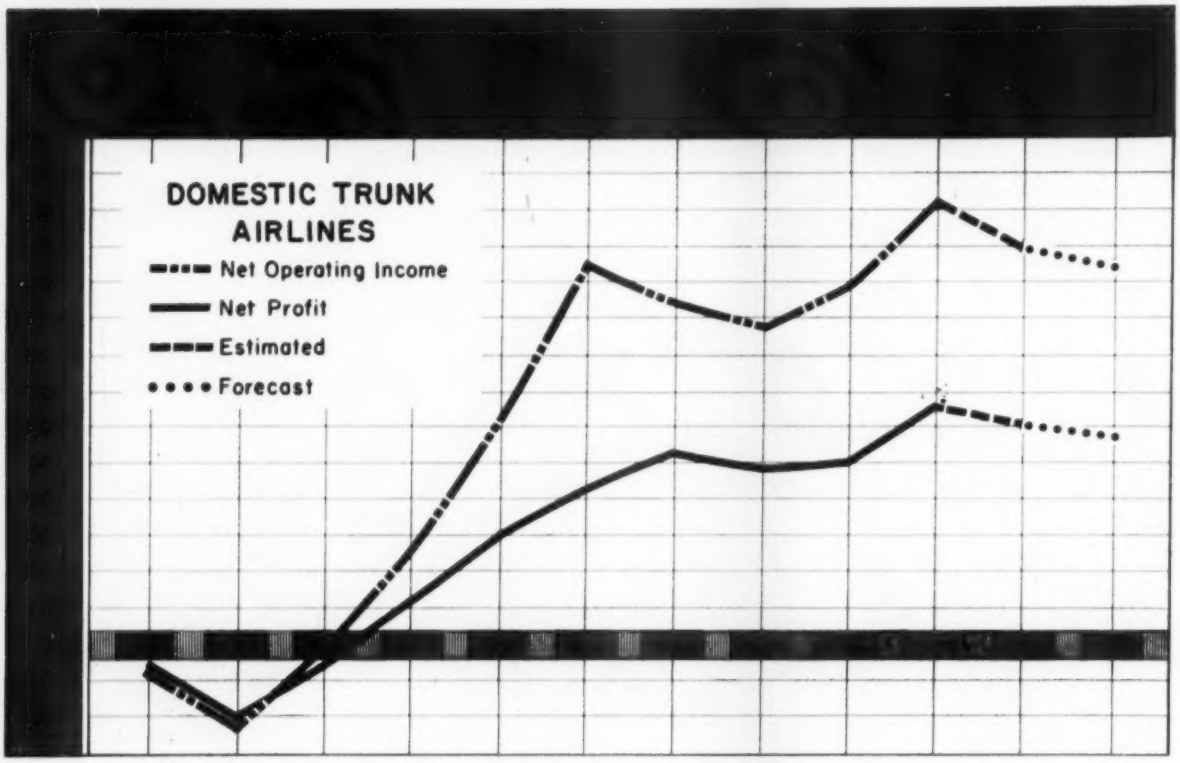


Trunk Traffic Gains But Costs Cut Net

By Craig Lewis

Scheduled expansion of trunk airline fleet capacity during 1957 indicates that this year's traffic gains should surpass the record increases in 1956.

While the carriers were busy last year handling record passenger and cargo traffic, they also took time to assess the problems that came with the rash of jet equipment orders placed over the last 18 months and they began to lay detailed plans for introduction of the jets.

Trunk airline revenues showed a healthy 11.1% increase to a total of $1,259,051,000 in 1956. Passenger revenues increased 11.5% to $1,139,366,000 to make up the bulk of the revenue gains.

Total traffic increased 13.3% to 2,482,927,000 ton-miles. Led by a booming coach business, the trunklines registered 21,811,993,000 passenger-miles, a 13.5% gain over record 1955 traffic levels.

Fleet Capacity Limited

The trunklines made these gains in a year which contained several prolonged periods of bad weather, a disastrous midair collision over the Grand Canyon, a steel strike and other factors which worked against traffic growth. In spite of these drawbacks, traffic increased by a margin matched only in the phenomenal boom of 1955.

The fundamental limiting factor in 1956 growth was fleet capacity, since deliveries of new transports were relatively small during the year. Deliveries are scheduled to increase substantially during the current year, and the added capacity, plus continuing expansion of the national economy, should produce traffic gains bigger than those of 1956.

The profit picture for the trunklines wasn't quite so rosy as the traffic and revenues would indicate last year, although it is far from bad. As revenues rose, expenses rose faster. The net result was that profits have tended to level off at 1955 levels and have not shared fully in the general expansion of business.

Increased Unit Costs

The carriers' unit costs moved steadily upward during 1956, reversing a long-term downward trend. Up to the end of 1955, increased efficiency and expanding business helped the trunklines keep their unit costs moving down.

Now the trend has reversed, narrowing the profit margin as the revenues increase.

One big factor in rising costs is the price of the current round of airline expansion. All of the trunklines have been expanding their systems in the past year. Primarily this was to handle the large number of new routes granted by the Civil Aeronautics Board during the past 18 months.

Much of the money for new facilities and new personnel must be spent before revenues from the new services begin to come in, thus increasing expenses faster than revenues. The costs of fleet expansion follow a somewhat similar pattern.

Heavy Gains for Coaches

Another factor in the narrowing margin between revenues and expenses is the growth of coach traffic and the resultant dilution of unit revenues. As coach service has developed since 1949, the average trunkline fare yield per mile has followed a generally declining trend.

Last year, coach business made heavy gains after a relatively stable year in 1955.

Between 1954 and 1955, the air-coach share of total traffic moved up only about two points to 34.5%. In

1956, coach traffic jumped close to the 40% level.

A key factor in this growth was the decision by United Air Lines to expand its aircoach market. Heavy new competition from United sparked increased activity by other carriers. American Airlines introduced its DC-7 Royal Coachman service, and Trans World Airlines maintained its historical position in the coach market with combination class Super-G Constellation services. All three decided to continue the $180 excursion fare introduced in 1955.

The expansion of Braniff Airways and Delta Air Lines routes to New York, as well as the development of longer routes by other carriers, also contributed to coach growth since the airlines concentrate coach services mainly on long routes.

Fare Investigation

A regulatory factor contributed to future uncertainty over trunkline profits when the CAB bowed to congressional pressure and launched an investigation of trunk passenger fare levels. When the review is over, there probably will not be any significant change in trunk fares, but the eventual result may well be a new fare structure that ties the fare level to the airlines' rate of return.

The carriers forestalled another CAB investigation by agreeing to a new plan to cure the no-show problem. A time limit for ticket pickup went into effect in September. So far, however, it has failed to make a significant dent in the problem. The carriers are now trying to decide whether they should go ahead with a plan to charge penalties for late cancellations and no-shows.

Another reservation problem cropped

Domestic Trunklines—Estimated Traffic and Revenues—1955, 1956

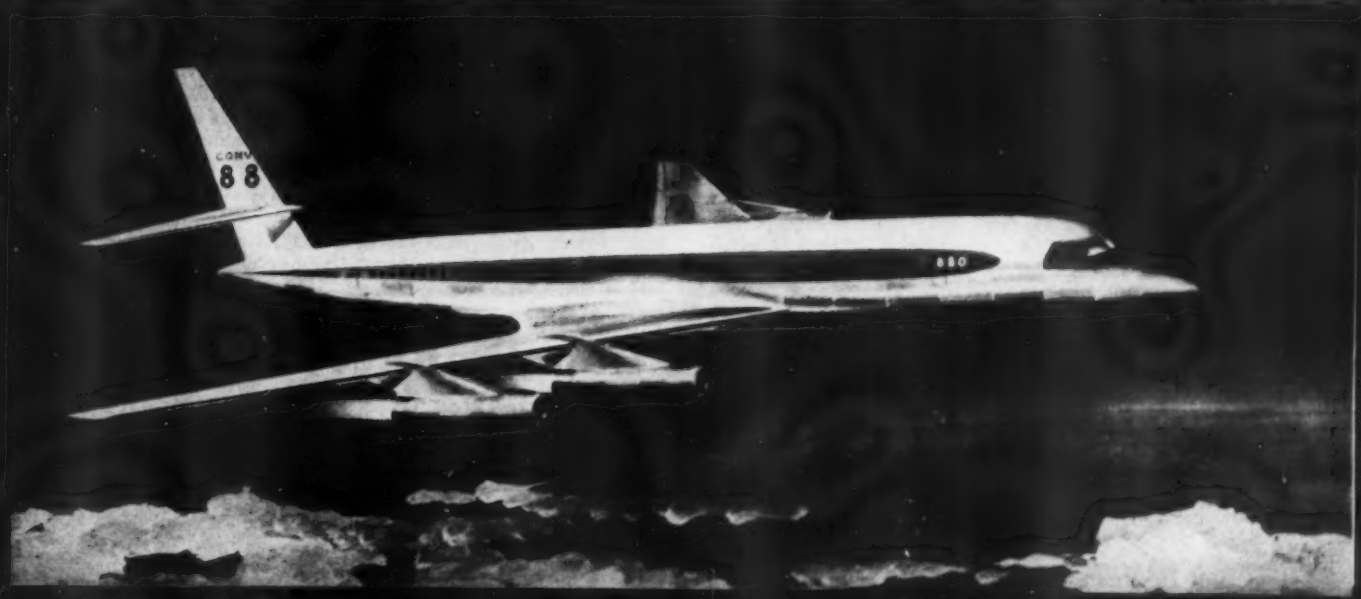
	1956	1955	Percent Increase
TRAFFIC	(000 omitted)		
Revenue Passenger-Miles	21,811,993	19,217,615	13.5
Mail Ton-Miles	92,900	86,034	8.0
Express Ton-Miles	52,775	49,608	6.4
Freight Ton-Miles	191,745	174,023	10.1
Revenue Ton-Miles	2,482,927	2,190,640	13.3
	1956	**1955**	
REVENUES	(000 omitted)		
Passenger	$1,139,366	$1,021,853	11.5
Mail	31,046	26,938	15.2
Express	19,307	19,404	(.5)
Freight	41,168	39,604	3.9
Other	25,408	22,356	13.7
Operating Revenues	1,256,295	1,130,155	11.2
Public Service	2,756	3,192	(13.7)
Total Revenues	$1,259,051	$1,133,347	11.1

Subsidy Estimates, Fiscal Years 1951-1958

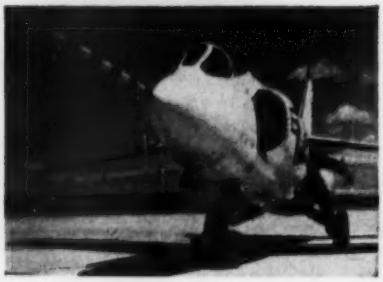
	1951	1952	1953	1954	1955	1956	1957	1958
	(000 omitted)							
Domestic Trunks	$17,612	$6,411	$3,527	$3,880	$3,055	$1,863	$1,163	...
Local service	17,310	18,990	21,800	24,300	22,637	24,907	27,087	$26,871
Helicopters	...	...	...	2,574	2,656	2,784	3,817	4,067
Mail-Cargo	...	...	...	...	...	...	...	...
Alaskan	3,276	5,431	7,865	8,307	7,727	7,643	7,527	7,375
Hawaiian	48	715	871	689	293	290	285	283
Trans Atlantic	10,382	5,837	4,182	1,625	203	611	873	...
Trans Pacific	10,776	11,641	12,173	6,461	...	67	378	...
Latin American	10,245	14,511	16,223	16,135	8,204	6,425	7,045	5,880
Total	69,649	63,536	66,641	63,971	44,775	44,590	48,175	44,476

Source: CAB Subsidy Report, Sept., 1956

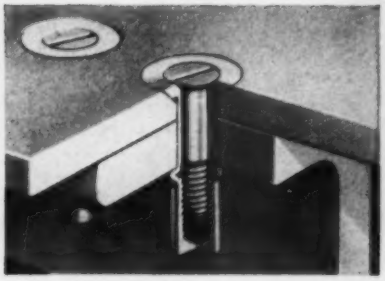
CONVAIR 880



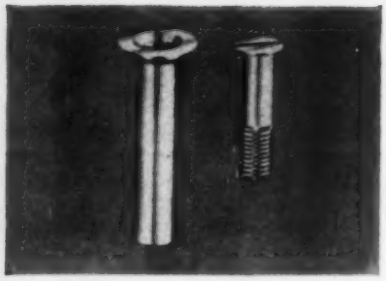
B.F.Goodrich solves tough sealing problems



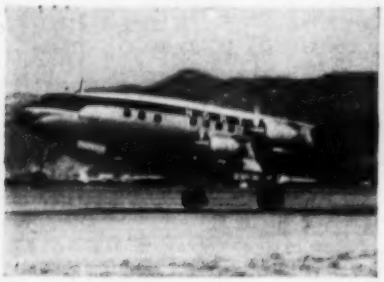
PROBLEM—Designing the Grumman F11F-1 Tiger, using skin panels for integral wing tanks, required a strong leak-proof blind fastener.



SOLUTION—Installed from one side, a Seal-Head Rivnut with rubber "O" ring provides a fuel-tight seal, withstands temperatures from −65° to +225° F.

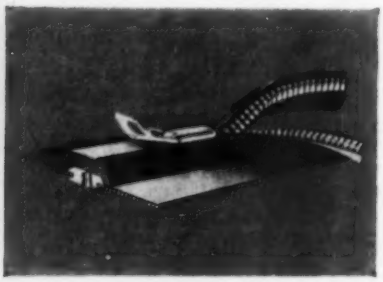


B. F. Goodrich Seal-Head Rivnut is approved for primary structure. Special high tensile screw adds reinforcement after installation.

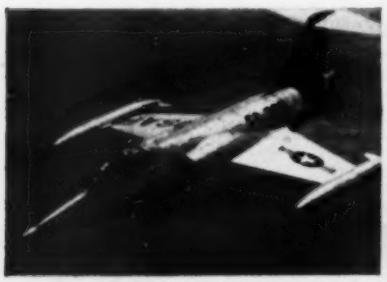


PROBLEM—Baggage compartment panels in Lockheed's Super Constellations had to seal out air, yet open easily for servicing of equipment.

SOLUTION—B. F. Goodrich baggage panels with Pressure Sealing Zippers zip open quickly, form flexible, air-tight bulkheads that withstand abrasion, impact.

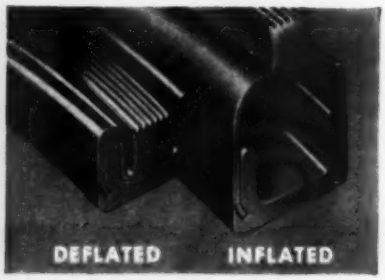


B. F. Goodrich Pressure Sealing Zippers have molded rubber lips that overlap with hairline precision. Three styles, two sizes, solve tricky sealing problems.



PROBLEM—The Lockheed F-104 required a lightweight canopy seal adaptable to compound curvatures, and offering high flexibility at low temperatures.

SOLUTION—BFG seal inflates without stretching, gives longer service life and uniform sealing pressure at all points.



Ribbed striker bead is lifted by quick-action, reinforced diaphragm. When inflation pressure is released, seal snaps into relaxed position without vacuum assistance.

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up during the year when the CAB warned airlines to curb overselling and overbooking as practiced by some carriers. And CAB decided to investigate airline-travel agent relationships, although the carriers have approved some reforms in the system since the review was ordered.

Most of the trunk airlines sat back during the past year and took a second look at their jet transport equipment programs. After the initial rush of orders at the end of 1955, 1956 was a period of mild activity in the equipment field.

Many of the carriers quietly increased their orders for piston equipment, but there was little ordering by trunks in the jet field.

880 Challenges Turboprops

Biggest event in the jet field was the advent of the Convair 880 with orders placed by TWA and Delta. This medium range turbojet challenged such turboprop transports as the Lockheed Electra for the market in the ranges below Boeing 707 and Douglas DC-8 operations.

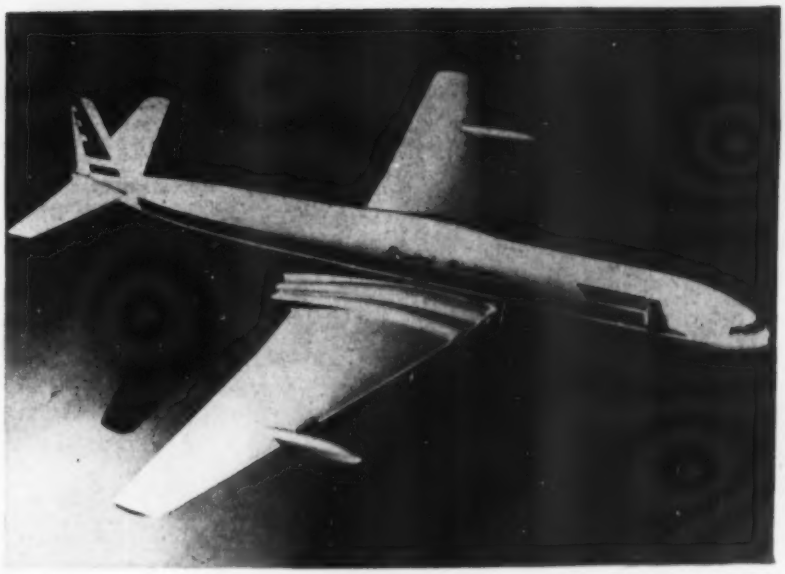
TWA and Delta are committed for the 880, and American, Western, Eastern, National and Braniff will fly the Electra. The rest of the airlines are still weighing the situation and trying to decide whether the small jet—such as the 880, the Douglas DC-9 or the Boeing 727—or the turboprop offers the most economical solution on medium routes.

British Widen Breach

The British widened their breach in the American market when they sold Capital Airlines the Comet IVA and Northeast Airlines the Britannia last year.

Capital and Continental Air Lines had already bought Viscounts, and Capital has operated them with considerable success on its routes.

Howard Hughes threw one of his periodic surprises at the industry last spring when he asked the CAB for permission to manufacture a new type



CAPITAL COMET MODEL

Total Traffic on U. S. Common Carriers

	1956 (EST)		1955 (ACTUAL)	
	Passenger Miles	Percent of Total	Passenger Miles	Percent of Total
Air	22,455,000,000	36.3	19,742,000,000	32.9
Rail	23,626,000,000	38.2	23,755,000,000	39.6
Bus	15,747,000,000	25.5	16,489,000,000	27.5
Total	61,828,000,000	100.0	59,986,000,000	100.0

Aircoach Statistics—1956, 1955 and 1954

CARRIER	REVENUE PASSENGERS			REVENUE PASSENGER MILES (000)		
	1956	1955	1954	1956	1955	1954
American	1,216,328	1,006,806	610,176	1,410,327	1,155,235	750,500
Braniff	126,612	79,142	29,980	88,621	39,906	16,296
Capital	228,189	236,587	331,629	116,811	117,811	146,851
Continental	59,528	49,700	12,277	32,357	27,308	6,755
Delta	628,508	338,741	228,333	421,682	280,978	165,378
Eastern	2,070,116	1,801,684	1,408,915	1,679,822	1,455,795	1,167,756
National	535,770	520,990	420,566	523,762	478,945	392,281
Northwest	354,143	333,124	322,894	335,361	295,232	293,750
T. W. A.	1,343,441	1,324,657	1,071,237	1,476,840	1,483,362	1,370,291
United	1,653,965	1,195,922	869,108	1,485,660	1,150,346	847,225
Western	231,355	338,128	298,314	126,376	169,733	151,092

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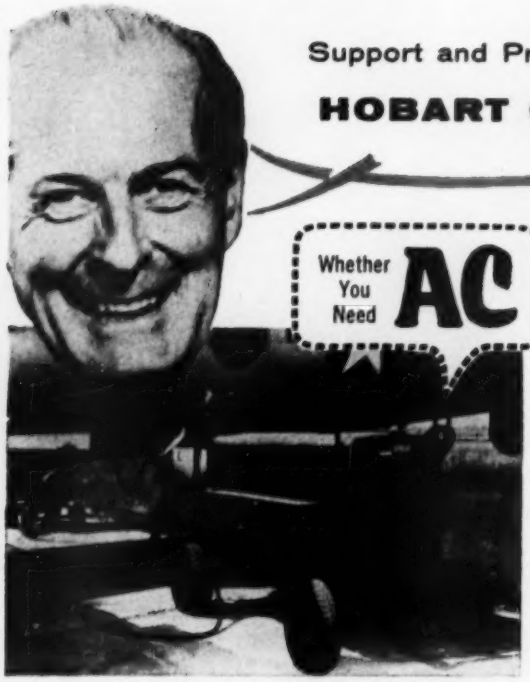

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Self-Propelled: This maneuverable ground power generator gets to the job under its own power. Saves cost and maintenance of separate tractors. Capacities of 600, 1000, 1500 amperes are in standard production.

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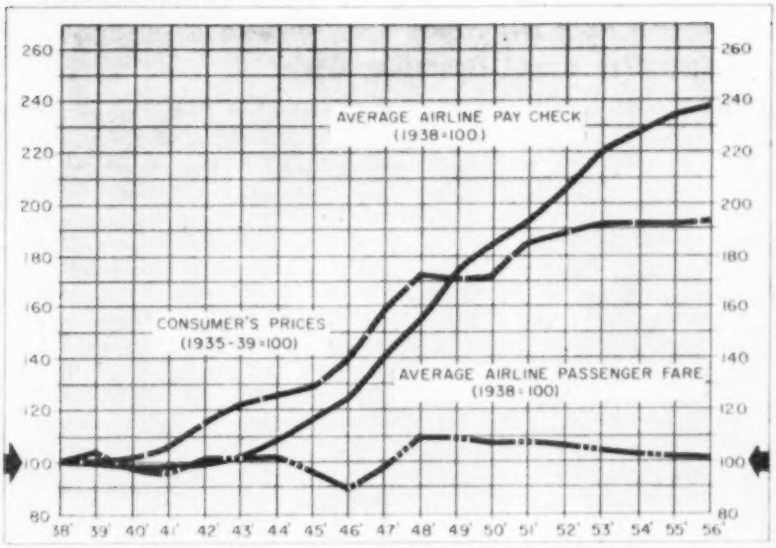

of jet transport for sale to TWA and other airlines. This proposal came after Hughes had ordered 707s and 880s for TWA. The Board set hearings on the plan, but they have been postponed and the project is apparently dormant.

Financing Problems

The airlines' financing problems raised by the coming jet fleets were complicated somewhat at the end of 1956 when the Office of Defense Mobilization decided not to issue any more fast tax amortization certificates for commercial transports. Although there is mixed opinion in the industry on the benefits of such tax aids, the airlines had applications on file for certificates covering about $1.3 billion worth of equipment.

When the ODM granted an extension of the commercial transport goal early in 1956, the certificates granted covered Capital's Viscounts, American's Electras and 37 of Eastern's 40 Electras. The rest of the carriers' jet orders were left out, and the prospects of ODM changing its mind and granting more certificates appear dim.

Planning toward introduction of the jets moved forward this year as the airlines moved past the big decisions on which type to buy and moved on to the more detailed decisions on how the big transports will be operated.

Several carriers set up special departments and special projects to study jet problems, and they are beginning to fly the jets now on paper to work out as many bugs as possible before the hardware comes along.

A possible complication in the introduction of jets developed during the year when it became apparent that the Air Line Pilots Assn. may insist on a third pilot on jets. But the most pressing problem remains the air traffic control system which has fallen behind present requirements and needs a major overhaul to handle future traffic with its high-speed jets.

Reorganized CAA

Last year marked a major upheaval in the Civil Aeronautics Administration, the agency which will have to bear the burden of revamping the traffic system. F. B. Lee left CAA in

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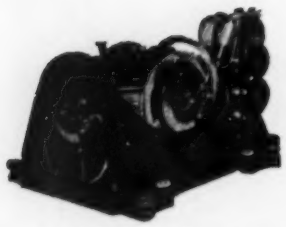

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MINNEAPOLIS
Honeywell
AERONAUTICAL DIVISION

Comparative Direct Operating Costs

(Cents per U. S. domestic plane-mile, 6 months ending June 30)

	1956				1955			
	Flying Operations	Direct Maintenance	Depreciation Charges	Total Direct Operating Costs	Flying Operations	Direct Maintenance	Depreciation Charges	Total Direct Operating Costs
DC-3	34.94	12.69	.74	48.37	34.72	11.08	1.67	47.47
CV-240	40.67	21.71	2.37	64.75	41.15	20.86	14.22	76.23
CV-340	41.56	18.37	16.10	76.03	42.75	17.83	17.61	78.19
2-0-2	44.16	23.57	21.01	88.74	46.43	16.51	27.70	90.64
4-0-4	42.65	21.90	14.70	79.25	42.80	18.45	26.17	87.42
DC-4	50.44	24.79	1.70	76.93	47.19	20.65	1.33	69.17
DC-6	54.73	22.66	4.87	82.26	54.53	20.82	10.83	86.18
DC-6A	54.50	15.23	23.89	93.32	52.56	21.10	26.24	99.90
DC-6B	66.11	21.90	17.08	105.09	64.21	18.21	17.34	99.76
DC-7	62.06	31.54	25.75	119.35	60.70	26.67	29.28	116.65
DC-7B	66.99	26.42	53.93	147.34	126.25	88.80	81.88	296.93
L-049	59.08	36.60	8.82	104.50	60.98	23.43	18.48	102.89
L-749	61.72	29.11	7.99	98.82	62.21	26.87	10.35	99.43
L-1049	71.22	31.56	15.51	118.29	68.92	29.61	33.85	132.38
L-1049C	71.53	36.39	40.38	148.30	68.81	35.27	43.01	147.09
L-1049G	70.70	45.82	40.71	157.23	70.66	9.00	47.07	126.73
B-377	78.21	39.74	40.29	158.24	90.26	36.47	35.21	161.94
Viscount	35.20	3.51	20.68	69.39	.....	.....	.....	.....

a flurry of controversy, and the agency has been reorganized, first under the leadership of the late Charles J. Lowen, then under James T. Pyle, the present administrator.

During the 1956 session, Congress gave CAA the money to launch its Five Year Federal Airways Plan for a $250 million overhaul of the air traffic system.

Then the tragic collision of TWA and United airliners over the Grand Canyon spurred Congress to increase CAA's appropriation and permit the agency to telescope its program into a three-year project.

CAB action failed to have the impact on the trunk airlines last year that it did in 1955, although the Board and President Eisenhower finally approved the Eastern-Colonial merger, and the roster of trunklines was reduced to 12 when the two merged June 1.

In 1955, CAB decided a series of route cases that rewrote the map of airline competition. All through these cases, the Board used a philosophy of helping the smaller trunks wherever possible in order to strengthen them and make them more capable competitors.

The CAB said it wanted to cut down the huge size gap between the Big Four and the remaining trunks. Traffic figures for the last months of 1956 indicate that the route decisions are having precisely that effect on the carriers, since the smaller trunklines are growing at a faster clip than the Big Four.

N. Y.-Florida Case

In the big decision of 1956, the CAB followed its 1955 precedent and chose Northeast Airlines to operate a competitive third service along the East Coast from New England to Florida. The Board's decision leaned heavily upon the need for improving Northeast's route system and allowing the carrier to attain true trunkline status.

Load Factors

Average Passenger Factors of the 12 Certificated Schedule Trunk Airlines for 1956 as Compared with 1955.

AIRLINE	1955	1956
American	67.99	68.47
Braniff	61.55	60.7
Capital	62.31	60.17
Continental	53.46	54.31
Delta	63.93	60.12
Eastern	60.96	60.74
National	64.09	65.91
Northeast	59.22	58.51
Northwest	59.72	61.25
Trans World	64.63	64.34
United	69.31	66.95
Western	59.10	61.90

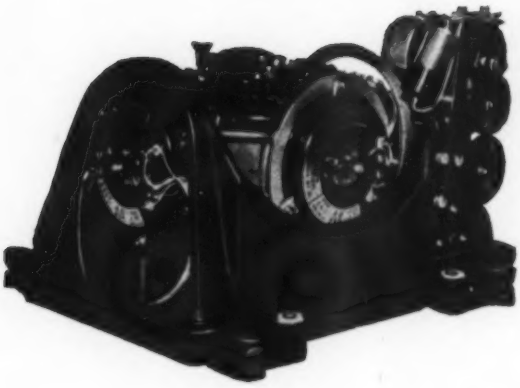
Source: CAB Annual Airline Statistics and Recurrent Traffic Reports.

The Board said it believes the new route, one of the richest in the world, will improve the financial position of Northeast and remove the carrier from the subsidy rolls almost immediately. Northeast is the last trunkline needing subsidy.

The Dallas-to-the-West case is the most important one now facing the CAB, and it will provide another test for the Board's current route philosophy.

American has a monopoly on routes from Dallas to the West Coast, and the Board will have to choose a carrier to offer competitive service.

Because of the Ashbacker Doctrine, which grants any carrier a part in a case if it can prove that exclusion would damage its interest in the matter, the Dallas case could turn into a Southern transcontinental route case similar to the long, bitter battle fought at the Board a few years ago.



Here is Honeywell Aero's new GG53A—the world's first cageable vertical gyro available with either synchros or resolvers that retain test-stand accuracy. An exclusive mounting preserves their accuracy after attachment to the gyro. Highly accurate—within 0.15° or better of true vertical—the GG53A is designed for vertical reference in flight control and radar stabilization, or for any system requiring angular position reference.

AERONAUTICAL DIVISION, MINNEAPOLIS-HONEYWELL

U. S. Aircraft Engaged in Air Transportation

SCHEDULED AIR CARRIER, DOMESTIC SERVICE

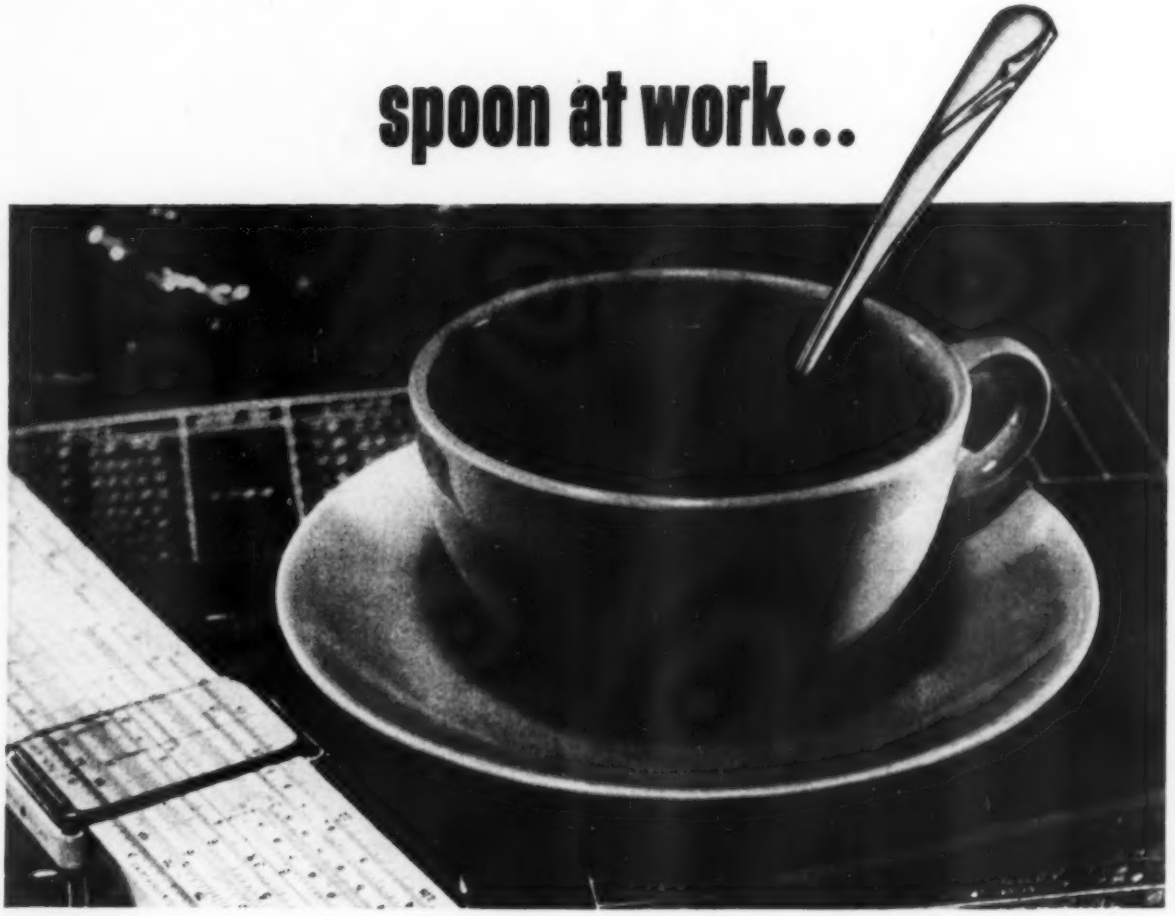
	Douglas						Viscount	Lockheed				Martin		Boeing	Convair			Total
	DC-7	DC-6	DC-6A	DC-6B	DC-4	DC-3	744	1049	749	049	18	404	202	377	440	340	240	
						15							5					20
	35	50	7	27	4												74	197
						9												9
		9				23				2						25		59
					15	17	28			12								72
						12												12
					5	8												13
				3		15									3	6		27
	11	7				16				4					1	20		59
	***19			2	9			*32	19			89						140
						13												13
						10												10
						9											4	13
	4	4		6							10				4	12		40
						21												21
					1	12											6	19
			6	4	18	6		4						9				47
						18												18
						19												19
						13												13
						10							7					17
						18												18
					10	4		37	39	32		38	11					171
	26	42	5	30	16	11										55		185
						14												14
				14	3	5											9	31
	95	112	18	86	81	298	28	**73	58	50	10	97	23	9	8	118	93	1,257

*Includes 18 L-1049C & 3 L-1049G **Includes 32 L-1049G (4 NWA; 28 TWA) ***DC-7B

	Douglas						Viscount	Lockheed				Martin		Boeing	Convair			Curtiss	Helicopter				Total
	DC-7	DC-6	DC-6A	DC-6B	DC-4	DC-3	744	1049	749	049	18	404	202	377	440	340	240	C-46	S-51	S-55	S-58	47G	
																				3		6	9
																			2	5			7
																				5	3	1	9
																		5					5
			5		8													17					30
					1													26					27
			6		7													13					26
						2																	2
						4																	4
					3																		3
	0	0	11	0	19	6	0	0	0	0	0	0	0	0	0	0	0	61	2	13	3	7	122
	95	112	18	86	81	298	28	73	58	50	10	97	23	9	8	118	93	3	0	0	0	0	1,260
	0	0	11	0	19	6	0	0	0	0	0	0	0	0	0	0	0	61	2	13	3	7	122
	95	112	29	86	100	304	28	73	58	50	10	97	23	9	8	118	93	64	2	13	3	7	1,382

*Operators certificated under CAR Part 45, engaged in scheduled intrastate passenger service utilizing large aircraft.

spoon at work...



A principle is at work, too! The same one by which a spoon creates a "silent cycle" of conduction, radiation and convection that cools the coffee—now, effectively applied, increases electronic equipment reliability.

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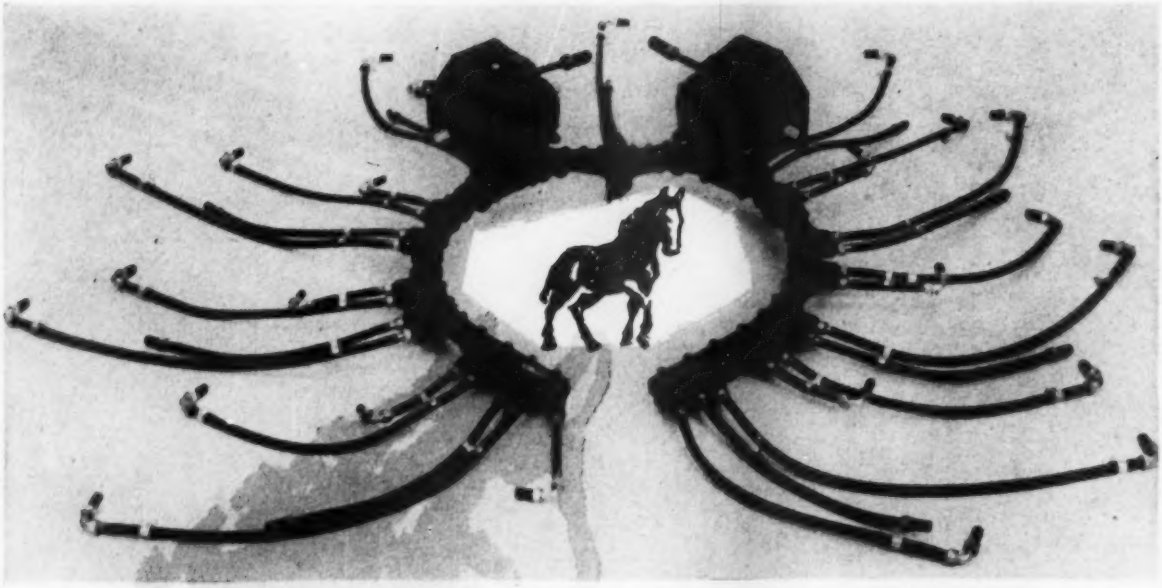

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Heavy Ocean Travel Aids U.S. Flag Lines

By Glenn Garrison

Steady growth of the mass international travel market during 1956 gave U. S. flag airlines grounds for encouragement, but not complacency, as their heavily mortgaged jet-age future drew nearer.

Travel to and from the United States reached all-time records. American airlines increased their share of the market—but so did the foreign airlines. Airlines expanded their piston fleets and sought new routes and markets which should change the airline map of the world.

Last year the American flag lines flew 5.08 billion revenue passenger-miles, a healthy 15% increase over 1955, but percentage-wise less than the 18% increase of the year before. Revenue gained 15%, reaching $443.8 million. This compares with an 8% increase in 1955. Subsidy payments, which had decreased sharply in 1955, totaled $1.6 million in 1956.

Cargo increased 20% to 107.4 million ton-miles, and U. S. mail carriage jumped 8% to 56.7 million ton-miles.

Once again tourist-class travelers emerged as the backbone of the international mass market. Over the North Atlantic, for example, tourist traffic accounted for the major increase. Some 576,000 tourist passengers flew the North Atlantic last year, an increase of 25%. First-class passengers totaled 209,000, only 10% higher than 1955.

Air Over Sea

For the first time, more people flew to Europe from the U. S. than went by sea. Totals for the fiscal year ended June 30, 1956, showed 404,701 air travelers and 380,087 sea travelers.

International travel to all other countries from the U. S. totaled 1,813,498 for the fiscal year, a 15% rise. Arrivals in the U. S. from other countries gained 13% to 2,071,130.

Airplanes carried 68% of all these travelers—a 20% greater share than in 1955. U. S. air carriers' share of the traffic increased 18%. But foreign flag airlines carried 26% more of the international traffic to and from the U. S.

Travel increased during 1956 from the U. S. to all major areas of the world except Africa. Travel to Europe was still the greatest source of activity, but more people were flying to other North American points, to Bermuda, the Caribbean and South America, and across the Pacific.

The airlines offered an increasing number and variety of tour packages,

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United States Aircraft Engaged in Air Transportation

SCHEDULED AIR CARRIER, INTERNATIONAL SERVICE

OPERATOR	Douglas						Lockheed					Boeing	Convair			Curtis	Miscellaneous		Total
	DC-7	DC-6	DC-4A	DC-6B	DC-4	DC-3	1049	749	649	049	18	377	440	340	240	C-46	G-21A	Misc.[1]	
[illegible]					3	3										***4			10
[illegible]																	9	5	14
[illegible]	*35	*50	*7	*27	*5										*74				198
[illegible]		*9																	9
[illegible]						4													4
[illegible]					*5	*8													13
[illegible]						2										***1			3
[illegible]	*11	*7				*16							*1	*20					55
[illegible]	*19			*2	*9		*32	*19											81
[illegible]																	8		8
[illegible]						8								5					13
[illegible]					1	2													3
[illegible]						1													1
[illegible]	*4	*4		*6							*10		*4	*12					40
[illegible]						4													4
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[illegible]					2	4			3										9
[illegible]	5[2]			5	2	4													16
[illegible]	16[2]		1	22	8							8							55
[illegible]		4	3	34(a)	21	2				1					5				70
[illegible]				4	5							18(b)							27
[illegible]						3												1	4
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[illegible]	*26	*2		*5															33
[illegible]						4										***5			9
	116	76	17	109	83	72	44	52	3	1	10	35	5	37	79	14	17	6	776

*Also listed on Domestic Certificate
**Operated in accordance with Provisions Special CAR No. SR-373A.
***Operated in accordance with CAR No. SR-388A.
[1]Includes 1, CH300; 1, PBY; 1, S-43; 1, Cessna 195 and 2 Piper Tri-Pacers.
[2]DC-7B.

6 DC-7B, 10 DC-7C
(a) 3 Also listed on Certificate 3
(b) On both Certificates 2 & 3

pay later plans and promotional incentives to moderate-budget traveler.

Pan American World Airways made a bid last spring to broaden the base of the international mass market by introducing a third, lower class airline fare. A high-density, no-frills transatlantic service with a New York-London round-trip fare of $390, the proposal set off a controversy among International Air Transport Association members meeting last June at Cannes.

Excursion Fare

Trans World Airlines also had offered a reduced fare plan prior to the IATA meeting. TWA sought a 15-day excursion fare of $350 for a New York-London round trip.

Civil Aeronautics Board favored the type of plan proposed by Pan American. Some foreign carriers criticized the proposed service as "airborne steerage" and resented CAB's pre-meeting announcement.

The Cannes meeting resulted in a compromise, with a New York-London excursion fare of $425 going into effect last Oct. 1. Third-class service was deferred until 1958. Whether IATA will implement it then remains to be seen.

Pan American, meanwhile, went ahead with a third-class service between the U. S. mainland and Puerto Rico.

New IATA excursion fare, and a new reduced fare for immigrants, are expected to help fill the transatlantic carriers' off-season seats. Post-season drop has been slightly less this year than last, but the Middle East crisis disrupting normal airline patterns in the area has obscured traffic factors.

Significant developments in several major cases before Civil Aeronautics Board affecting the U. S. flag carriers occurred during 1956.

Both Pan American and TWA were recommended by the CAB examiner for service over the direct "polar" route from the West Coast to Europe.

Pan American is expected to receive authorization to fly from Los Angeles, San Francisco and Seattle to Europe via the polar route now flown by two foreign carriers. TWA was recommended for service from Los Angeles and San Francisco via the same route.

CAB examiner found 79,000 passengers a year to be a reasonable estimate of traffic over the route.

New Global Service

A second U. S. flag global service has been provided by CAB and approved by President Eisenhower. TWA's Far East route was extended from its old terminal at Colombo, Ceylon, to Manila via Bangkok, Thailand. Northwest Airlines will link with TWA

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at Manila, providing the first U. S. competition to Pan American's round-the-world service inaugurated in 1947.

CAB in 1946 had authorized a TWA-Northwest link at Shanghai, but it had been made impossible by the Chinese political situation.

A more competitive situation over the Pacific also may result from Pan American's step toward a partial victory in its long-standing battle for a Great Circle route between the West Coast and the Orient.

In the reopened Trans-Pacific Renewal Case, the CAB examiner recommended that Pan American be authorized to fly the direct route between California and Japan. If the recommendation is endorsed, Northwest will face tough competition.

The examiner supported Northwest, however, in its opposition to a Seattle-Tokyo route for Pan American. This direct invasion of its market would have been the most serious blow to Northwest. Both of the airlines now are subsidy-free in their Pacific operations, partly as a result of a Defense Department shift of military mail to commercial carriers.

Traffic over the Pacific has increased considerably during the last four years, growing from 26,715 passenger in 1952 to more than 51,800 in 1955. Estimates indicate a 1957 total in excess of 72,000 passengers.

Asia Traffic Up

Travel from this country to Asia has increased 64% since 1952, and for Fiscal 1956 gain was 24% over Fiscal 1955. Travel to Japan accounts for 60% of all travel from the U.S. to Asia. U. S. flag carriers handled 51,623 passengers out of the total 59,717 who flew from the U. S. to Asia in Fiscal 1956.

In another route case, Pan American won out over Eastern, National and Mackey when CAB decided to give PAA a route between New York and Nassau. The airline's five-year certificate for the route prohibits single-plane service between New York and Miami via Nassau, or advertisement of a New York-Miami service.

CAB estimates that Pan American will capture 60% of the market against British Overseas Airways Corp. competition and fly 37,400 passengers over the route this year. PAA's revenues on the run will total $2,313,000 during the first year of operation, the Board estimates, with a $500,000 profit to help reduce subsidies.

Pan American lost its fight for a New York-Miami route last year when CAB decided for Northeast Airlines.

Airline routes from the U. S. to Bermuda, the Caribbean and South America are increasingly busy with vacationers and business travelers. U. S. carriers continue to handle the major

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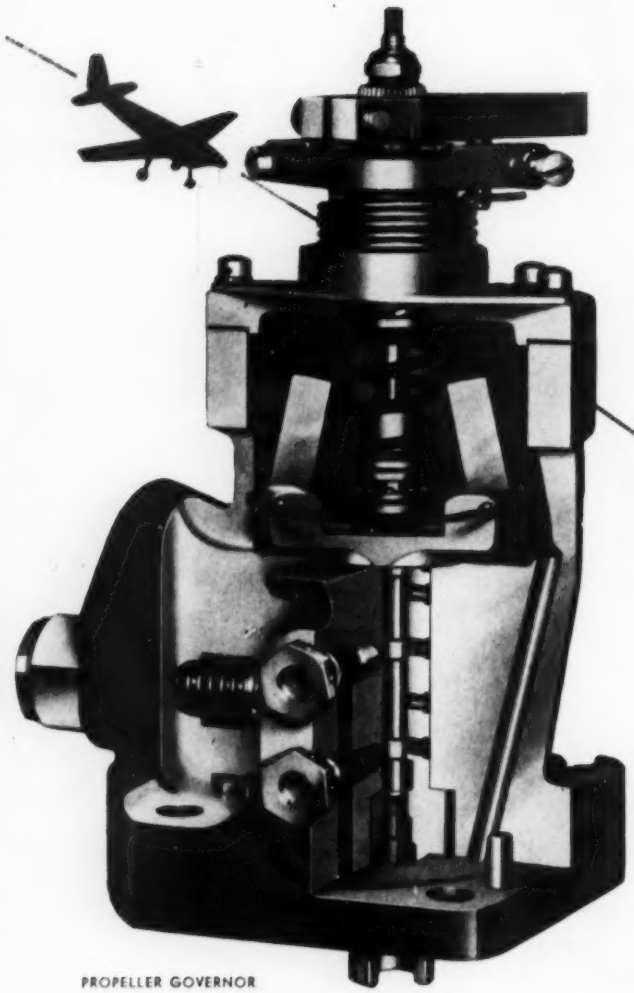
WOODWARD AIRCRAFT GOVERNORS



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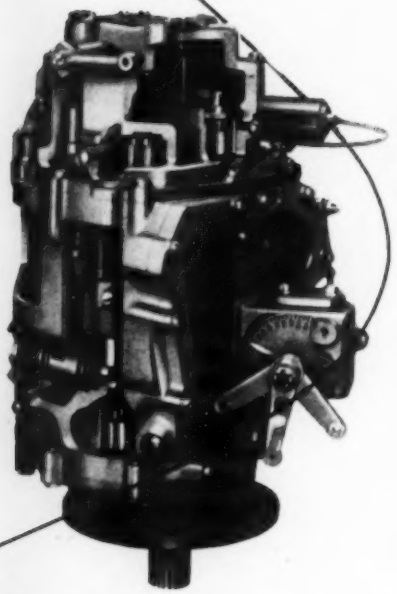

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share of the traffic. Last year, Pan American, Braniff and Panagra cut South American fares about 30% for excursion groups. The airlines are pushing sales in this area with many budget tours and packages.

Eastern Air Lines gained important routes to Canada and Bermuda last year with the acquisition of Colonial Airlines. Eastern began operating Constellations to Montreal and Bermuda, plans to put DC-7B or Super-G equipment on these highly competitive runs this spring.

The U. S. flag carriers continue to expand their piston fleets to keep up with the growing traffic. The long-range Douglas DC-7C made its appearance last year as Pan American inaugurated the first regularly scheduled nonstop service from New York to Paris. Significantly, Pan American put its new planes into mixed-class service, pointing up an increasing trend toward such utilization.

Braniff began receiving its DC-7Cs last fall, put the aircraft on domestic routes to meet competition. The airline plans to use DC-7Cs on its international routes to South America this spring.

Northwest will be flying the DC-7C over the Pacific sometime this year.

TWA's prime equipment during 1956 continued to be the Super G Constellation, but the airline will be adding new 1649As to its trans-Atlantic fleet this year.

Delta received the first of its DC-7B order early this year, but, like Braniff decided to use its new planes initially in domestic competition. Some DC-7Bs will go into Delta's international service this year, along with some Convair 440s on Caribbean segments.

Turboprop Equipment

Turboprop equipment should begin showing up on shorter international routes in early 1959.

Eastern will receive its first Lockheed Electras in the summer of 1958 and probably will put some into U.S.-Canada and U.S.-Bermuda service after the heavy Florida season is over.

American's Electras will start arriving late next year, and some might eventually go into New York-Toronto service. American now flies DC-6 series equipment on this run in competition with Trans-Canada Air Lines' Viscounts, faces TCA Vanguards in 1961.

Braniff has ordered nine Electras and could put some of them into South American service while waiting for straight jet equipment. National Airlines has ordered 23 of the turboprops, might use some New York to Havana.

All of the U.S. international carriers, except Northwest have committed themselves to the big jets.

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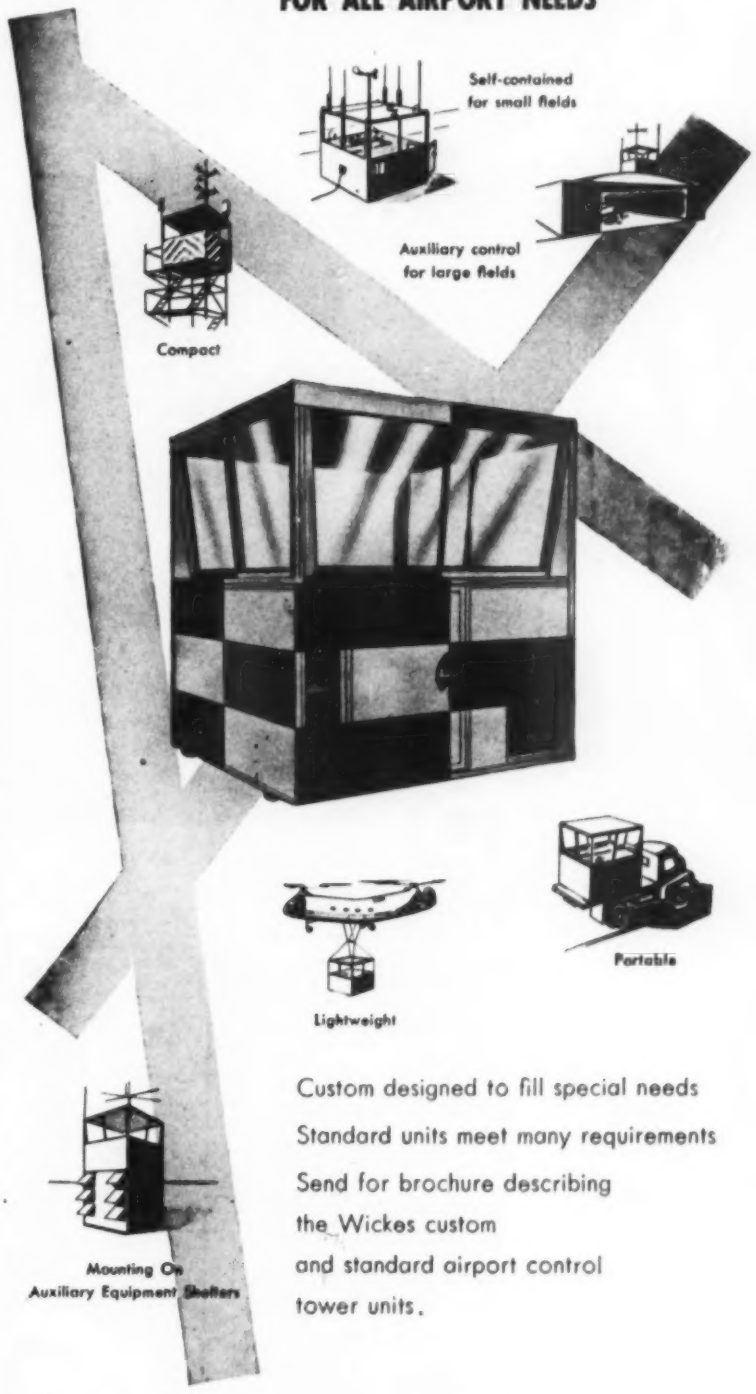

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Mixed Outlook for Local Service Airlines

By Katherine Johnsen

Outlook for local service airlines is for a continued fast growth for an indefinite period, but also an uncertain financial future.

Since the first local operation was certificated a decade ago, the industry has grown to a $66.8 million business. The outlook is that it will reach the $100 million mark within a few years.

In 1956, traffic and income growth continued at a high rate:

- **Passenger revenues** of over $40 million reflected a 23% increase over 1955, and were five times more than the $8 million for 1950.
- **Total operating income** of $66 million represented a 16.7% increase and three times more than the $22 million for 1950.

Route Expansion

The 1956 expansion in routes and service, however, was modest:

- **Route miles** (unduplicated) increased from 27,913 in 1955 to 31,740.
- **Number of stops** served went from 341 to 359, and the population served from 53 million to 54 million.

The subsidy requirement climbed a moderate eight percent to $22 million, but this was substantially higher than the $12 million for 1950.

These two factors point to the industry's continued growth:

First, the market for short-haul traffic has barely been tapped by the air carriers. John Floberg, chairman of the Conference of Local Airlines, says:

"Since the airlines carry less than 2% of all common carrier passengers on journeys of less than 250 miles, it seems apparent that better service and better equipment create a great likelihood of continued growth toward a higher percentage of that market. Just achieving a four percent penetration, for example, would mean more than doubling the current volume of traffic. These figures do not even consider the almost unlimited market available in the diversion of passengers from our principal competition—the private automobile—which, on the typical local service segment, is an extremely formidable competitor."

Second, numerous proceedings are underway or contemplated by the Civil Aeronautics Board to fill gaps in the nationwide route network of local airlines.

The trend to eliminate intermediate stops on trunk routes continues. CAB cases include:

- **Seven States Case,** covering the Dakotas-Nebraska-Kansas general area. Braniff Airlines, Western Airlines and Northwest Airlines plan to drop stops in

	Revenue Passenger Miles	Passenger Revenue	Subsidy	Total Operating Income
1950	160,425	$8,067	$12,718	$22,301
1955	523,298	32,841	20,714	57,242
*1956	641,040	40,477	22,381	66,803
Percentage Increase 1956 over 1955	22.5%	23.3%	8%	16.7%

* Estimated

	Passenger Revenue	Subsidy	Total Operating Income	Net Operating Income (Before Taxes)
Allegheny	$3,951	$1,758	$6,024	$−150
Bonanza	1,526	1,207	2,920	214
Central	1,054	1,887	3,064	26
Frontier	2,900	1,835	5,636	204
Lake Central	1,219	1,193	2,554	16
*Mohawk	3,626	517	4,448	−311
North Central	5,721	1,142	7,339	140
Ozark	2,892	1,751	5,490	11
Piedmont	4,409	1,804	6,668	−347
Southern	1,781	1,503	3,533	−100
*Southwest	2,671	1,036	3,973	−140
Trans Texas	2,735	2,117	5,164	−243
West coast	1,969	1,475	3,579	6
TOTAL (11 months 1956)	36,544	19,227	60,392	−674
TOTAL	32,840	20,714	57,242	304

* For 10 months to Nov. 1, 1956

	First Class	Aircoach	Total
1956	5.76	4.38	5.26
1955	5.83	4.35	5.32
1954	5.87	4.15	5.36
1953	5.88	4.13	5.44
1952	5.86	4.16	5.55
1951	5.75	4.47	5.59
1950	5.76	4.17	5.54
1949	5.83	3.98	5.76
1948	5.74	....	5.74
1947	5.03	....	5.03
1946	4.62	....	4.62

Note: First class yield has been adjusted to include all traffic other than coach.

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this area. Several local lines are ready to extend their routes from the east, south, and west into the area. These include Frontier Airlines, North Central Airlines, Ozark Air Lines and Central Airlines. A Board decision is expected early in 1957.

• **Great Lakes case,** covering the Michigan-Ohio-Indiana-Illinois general area. The CAB has proposed that American Airlines, Capital Airlines, Delta Airlines, and Trans World Airlines drop points. Lake Central Airlines, Allegheny Airlines and North Central are involved in the case and could move into points dropped by trunk lines.

• **Montana Service case,** covering the Pacific Northwest-eastward area, and involving West Coast Airlines and Frontier Airlines.

• **Pacific Northwest-Southward case,** involving Southwest Airways, Bonanza Airlines, and West Coast Airlines.

• **Northeast case,** covering the New England area, involving Mohawk Airlines and Allegheny. Northeast Airlines, since obtaining a New York-Miami route, is inclined to drop its local services in the area.

Eventual expansion of local service operations in the Florida and Southwest areas also is expected.

The route expansions will add to the industry's financial problems and take it further away from the goal of self-sufficiency. It is estimated that proposed extensions could increase the total industry subsidy requirement by $20 million annually.

Re-Equipment Burden

Another major problem facing the industry is its re-equipment program. Replacement of the fleet of 150 DC-3s with a more economical aircraft has long been recognized as a "must."

At a 65% load factor—the theoretical maximum—the DC-3 would still yield passenger revenues of only 81.9 cents per mile. Other commercial revenues would raise this to 87.5 cents. The minimum operating cost is $1 per mile.

"The consequent gap," Floberg says, "will invariably have to be filled by public service revenues in the form of government subsidy."

A one-for-one replacement of the DC-3s with a $500,000 aircraft would mean a total industry investment of $75 million.

The cost of the Fokker F-27 is $540,000 with accessories. To be produced by Fairchild Airplane and Engine Co., it is considered by Floberg as the only replacement prospect at this time, although Douglas Aircraft Co. is working on designs for another short-haul plane.

Last year four carriers placed orders and options for 44 F-27s scheduled for delivery in 1957 and 1958—an investment of $23.8 million. West Coast ordered four with four options; Pied-

mont, twelve and twelve options; Frontier, four and two options; Bonanza, three and three options.

Two developments promise to ease the industry's financial position:

• **Profit allowances.** After long and persistent protests by the industry that CAB cost and profit allowances have been inadequate, the Board has ordered an investigation "to determine whether the rate of return or profit element currently allowed . . . is generally fair and reasonable and if not, to determine a fair and reasonable rate of return or profit element for the local service carriers as a class."

The order was issued in the face of possible congressional hearings and was interpreted by some as a step to forestall one. The industry is prepared to take its case to Congress in hope of pressuring the Board into action. Floberg told a House subcommittee last summer that:

"In spite of 10 years of progress, growth and constantly increasing public service, there is no history of financial reward for the local service industry.

"None of the 13 local airlines has ever paid a dividend, and yet none has large financial reserves capable of supporting the impending, absolutely essential re-equipment program. . . . There has never been a year when the industry has had an earned surplus."

• **Equipment sales.** The major item on the local lines' legislative agenda is a measure that would permit them to set aside earnings from equipment sales for the purchase of new equipment. In cases involving Pan American World Airways and Trans World Airlines, the CAB established a policy that earnings from equipment sales offset subsidy.

The outlook for enactment of the equipment sales legislation is excellent. The measure passed the Senate last year, but opposition in the House delayed action until Congress adjourned. The opposition was based on the claim that the measure would result in a "windfall" to a few international carriers, and be of only minor value to the local lines.

Other proposals to improve the local service lines' financial status include:

• **Access to high density traffic** points. There is strong pressure from Congress for the CAB to extend local routes into the larger cities.

• **More favorable distribution** of interline ticket revenues to the local service lines. This was advocated by former CAB member Joseph Adams.

The local lines are apprehensive of CAB's investigation of trunk line fares —which seems likely to lead to compulsory reductions. Since they serve many of the same points, the local lines feel that they would have to follow through with similar reductions.

Floberg says the investigation has developed serious repercussions in the money markets where the local airlines hope to find support.

"Not only does its history give rise in some quarters to a suspicion that this is an industry where profits—not 'excess profits' but any profits— are forbidden by government policy, but talk of 'excess profits' and the implication of inevitable reduction in airline revenues makes the skeptic fear that the suspected policy is irreversible."

Arguing for more lenient treatment, Floberg emphasizes these points:

• **Local lines return** $14 to $15 million annually to the federal government —over $3.3 million in transportation taxes; $832,280 in fuel taxes; over $2 million in payroll taxes; about $8 million in postage from mail generated.

• **Local lines contribute** to national defense as available airlift for the military services in an emergency. The plane maintenance and operating cost and the personnel cost of the industry approximates $30 million annually.

• **Because of local service,** many small towns in the U.S. now have the same aircraft traffic volume as major world cities. There is comparable traffic at Yakima, Wash., and Copenhagen; Fresno, Calif., and Frankfort; Ontario, Calif., and Paris; Pendleton, Ore., and Nice; Evansville, Ind., and Hamburg.

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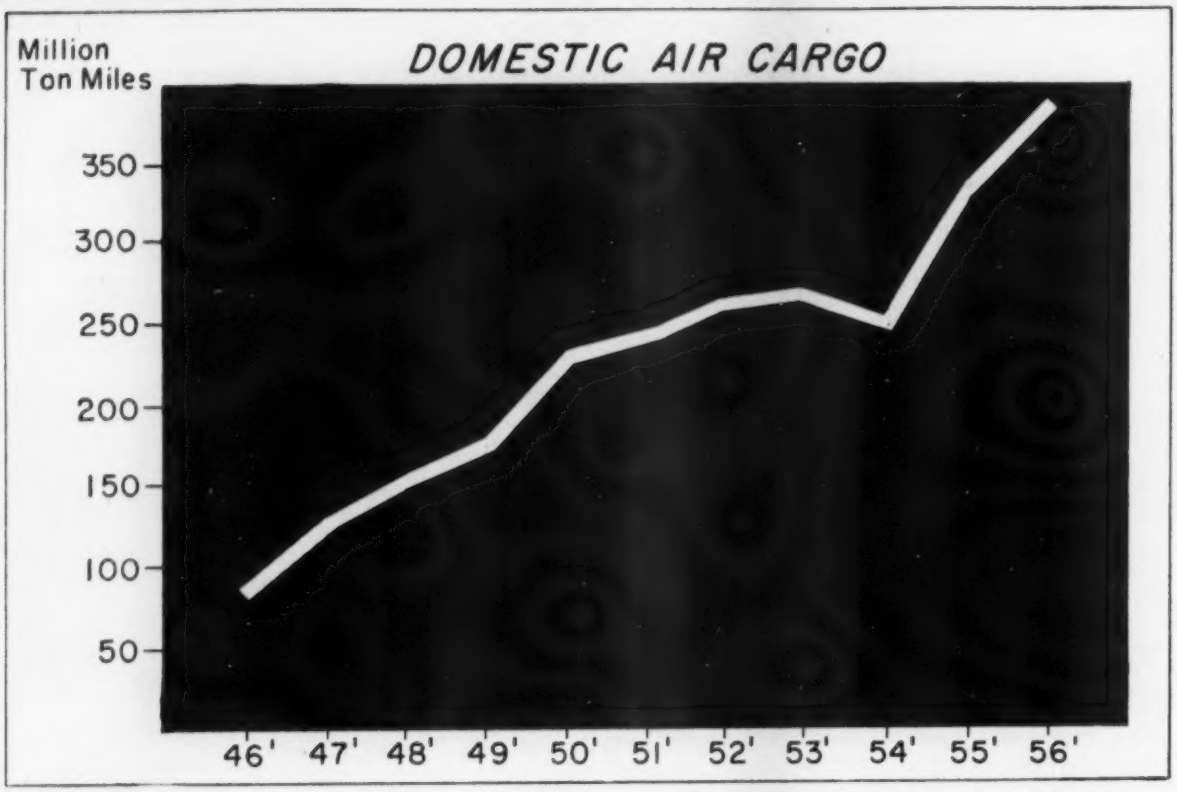

Air Cargo Gains Fall Short of Potential

By L. L. Doty

Washington—Air cargo business improved substantially in 1956. Although the volume of freight handled again fell short of the growth potential, greater market penetration in 1957 is expected.

In a year of stable expansion, air cargo reflected the growing demand for faster distribution of goods. However, most cargo officials admitted the airlines were lagging far behind in capturing their share of the freight market.

One airline estimated the airline industry is handling less than one-thirtieth of one percent of intercity cargo traffic.

Freight ton-miles handled by all U. S. domestic and international airlines in 1956 climbed 14% over the previous year, a disappointing gain compared to the 19% increase in 1955. Ton-miles of all freight handled in 1956 totaled 446 million, air cargo accounting for 437 million. Mail ton-miles were 154 million, express 55 million.

Industry spokesmen claim the high freight rates will prevent any substantial breakthrough during the next few years. They add: "We can't cut rates until high operating costs are sliced by the use of more economical cargo aircraft."

This enigma places the airlines in a weak competitive position against the railroads. Average freight charge by the scheduled airlines is 22 cents per ton-mile with all-cargo operations drawing 18 cents. This compares to a railroad Class 1 freight rate of 2.5 cents per ton-mile and a truck rate of six cents. This leaves the airlines but one sales wedge: speed.

T. J. Harris, director of cargo sales for American Airlines, has charged that lower rates and better airfreighters won't do the entire job. He accuses the industry of failing to develop a sales technique based on sound economic knowledge of transportation costs in relation to other aspects of production, distribution and inventory control.

Renewed Emphasis

Capital Airlines' cargo sales head, Guy Springer, echoes this view and has declared, "airfreight is no longer a means of carrying orchids but is a day-in and day-out method of cargo transportation that can have a dramatic effect on distribution."

Last year, the Air Transport Assn. placed a renewed emphasis on air cargo sales and promotion through the organization of air cargo committees within the Air Traffic Conference.

But most cargo officials held high rates as the roadblock to greater freight expansion. They see little hope of an early reduction in air cargo charges and look to deferred freight and special commodity and directional tariffs as the only immediate means of attracting new business.

New Equipment

Two hopeful prospects for the airlines lie in the railroads' recent move to hike some freight rates by 15% and a gradual trend among the scheduled airlines toward the replacement of the uneconomical C-46 and DC-4 airfreighters with the less costly DC-6A and Lockheed 1049H.

Flying Tiger Line will begin Constellation airfreight service next month with the first two of the 10 Lockheed 1049Hs it has on order. Robert Prescott, president of the airline, told AVIATION WEEK that the "Connies will be the first real test of air freight business." He forecast a slow first six months but predicts the second half of 1957 will be the biggest six month period in the company's history because its fleet of

five DC-6As and 10 1049Hs will then be in full operation.

Direct operating costs of the DC-6A are about 30% less per ton-mile than either the C-46 or DC-4 and an even greater saving is expected from the 1049H airfreighter.

However, Riddle Airlines expects increased success from its C-46s as a result of a conversion to the T category of the aircraft which will increase payload by 2,000-lb., and increase speed from 225 mph. to 230 mph. at 9,000 ft.

California Eastern has three 1049Hs on order, Seaboard and Western five and U. S. Overseas Airlines, two. All orders are to be delivered this year. Resort is presently operating two 1049Hs.

United Air Lines began DC-6A all-cargo service in July of last year with a fleet of five of the airfreighters in addition to eight all-cargo DC-4As. American Airlines operates all-cargo flights with seven DC-6As and six DC-4As.

Jet Freight

The jet age will prove a bonanza to the scheduled airlines since cargo capacity of the Lockheed Electra in passenger service will be 2,000 lb. and the Boeing 707 will accommodate 4½ tons of cargo in addition to its passenger payload.

In July, Flying Tiger's Robert Prescott stated he had consulted with Boeing on the possible use of the 707 jet transport for cargo operations and that an operating cost figure of 3½-4 cents a ton-mile had been discussed for a 75,000 lb. payload over an 800-mi. run. California Eastern in November placed an order for four Convair 880 jet transports

Meanwhile, cargo men would like to see commercial application of such freighters as the C-132 or C-133 to all-cargo operations.

Most airlines have found that all-cargo operations are a marginal enterprise at best, showing little profit even at today's high rates. On the other hand, the transportation of cargo on passenger planes on an added cost basis has proved to be an economical operation. In addition, cities not justifying an all-cargo service are provided a daily scheduled freight service when passenger aircraft are used in cargo service.

Rate Conflict

This problem could cause a sharp split between scheduled airlines certificated for both cargo and passenger and the all-cargo airlines. In November, the Flying Tiger Line asked the Civil Aeronautics Board for permission to raise present minimum freight rates by 3% because of increased operating costs. American Airlines immediately asked the CAB to dismiss the petition.

One airline official accused the passenger airlines of wasting cargo space on passenger aircraft and pointed out that less than one-half of the available cargo space is being used. If 50% of this unused space had been filled with cargo, he maintained, the airlines would have realized an additional $80 million in gross revenues last year.

The airlines would like to get more of the military cargo business and last year the Air Traffic Conference passed a resolution authorizing their Joint Airline Military Ticket Offices (JAMTO) to handle cargo business as well as passenger and commercial air movements for military installations.

In Fiscal Year 1955, trucks received 52% of the military cargo business with the railroads taking 44%. The small balance was shared by barge and steamship lines, Railway Express and the airlines.

In June of last year, Resort Airlines, Capitol Airways, Riddle Airlines and American Air Export and Import Airlines were successful bidders among 14 carriers for a total of $15.5 million in

AMERICAN CARGO LOADING OPERATION

UNITED DC-6A CARGO PLANE

Air Cargo: 1956—1955

TON-MILES

	MAIL		EXPRESS		FREIGHT	
	1956	1955	1956	1955	1956	1955
TRUNKLINES						
American	20,042,045	18,101,987	10,750,415	11,083,333	71,395,966	67,030,262
United	26,913,285	25,103,908	12,748,567	12,791,971	50,149,731	39,553,351
TWA	12,550,670	12,964,881	9,090,353	8,407,014	23,698,613	24,423,863
Eastern	11,284,254	10,063,637	5,341,545	5,384,454	14,672,350	14,006,219
Northwest	4,642,008	4,821,522	2,720,771	2,655,006	7,755,427	6,581,930
Delta	3,824,223	3,299,168	3,219,827	2,697,462	7,228,971	6,614,630
National	3,289,957	3,138,812	703,367	708,703	4,986,205	4,262,543
Others	9,063,917	8,873,702	5,115,753	5,656,887	10,865,806	13,456,547
	91,070,359	86,067,617	48,690,608	49,584,830	190,752,269	175,929,345
CARGO LINES						
Aaxico*						
Aerovias Sud-Americana	.....	.....	.....	.....	8,047,840	6,561,148
Flying Tiger Line	365,187	60,868	298,616	.....	67,617,048	49,882,572
Riddle	††	35,665	.....	.....	42,000,000†	14,314,808
Slick	787,788	150,021	547,303	.....	47,719,358	47,461,228
	1,152,975	246,554	845,919	.....	165,384,246	118,219,756

* Main Freight Activity Under Logair Contracts
†† Estimate
† Unavailable

Logair contracts for the Air Materiel Command in Fiscal 1957. AMC holds options to extend contracts to Fiscal Years 1958 and 1959.

Slick, Tiger Renewals

Slick Airways and Flying Tiger Line last year won a five year renewal of their operating authority in a Civil Aeronautics Board decision on the east-west portion of the airfreight renewal case. At the same time, Slick, Flying Tiger Line, Riddle and American Export and Import were given rights to carry air mail and air express for the first time.

American Airlines again lead in airfreight activities during 1956 with air freight revenues totaling $15.8 million for the year. The airline flew 74 million ton-miles of cargo and expects 100 million this year. American will take delivery on three additional DC-6As this year to increase its total daily lift capacity to 400,000 lb.

The airline put increased emphasis on airfreight activities by upgrading the cargo section to departmental status with the election of Samuel Dunlap as vice president of cargo. Deferred airfreight was introduced by the airline last year.

United Air Lines flew an estimated 51.3 million freight ton-miles in 1956, a 27% increase over 1955. R. L. Mangold, manager of cargo sales, forecasts a 5-10% increase during 1957, a lesser increase in air mail ton-miles and no substantial increase in express volume.

Trans World Airlines carried 24 million ton-miles of airfreight in 1956, a drop of one percent over previous years. Air express increased 7.5% and air mail and first-class mail, accounting for 14 million ton-miles, declined 3.4%.

On the airline's international routes, air cargo ton-miles totaled an estimated 9 million ton-miles, an increase of 8.8% over the previous year. S. E. Russ, TWA cargo sales manager, plans to emphasize air cargo through education as part of his 1957 program. He said: "TWA will try to show the business community the true economics and advantages of air freight."

Riddle Doubles Volume

Riddle Airlines recorded an increase of more than 100% in ton-miles handled during 1956 and is forecasting a volume in excess of 70 million ton-miles for 1957. American Air Export and Import Co. is devoting its main efforts to its Logair contract and is now operating 3.8 million ton-miles monthly with 14 C-46s.

Flying Tiger Line held second place among all carriers in freight ton-miles handled. During 1956, the airline carried 67.6 million ton-miles of cargo compared to 52.4 million in 1955. Deferred freight was introduced and 2,000 lb. of this type of cargo was handled during June, the first full month it was in effect. By the end of the year, deferred freight had jumped to approximately 30,000 lb. per month.

Slick Airways carried 49.4 million ton-miles of cargo in its common carrier operation in 1956, a new company record. According to John Muhlfield, Slick vice president of sales and traffic, total revenue miles last month reached 4.3 million, a 45% increase over last January.

Gross revenues for the year rose to $22 million, almost double 1955's $12.5 million gross. Slick President Robert Smith credited last year's improvement to an increase of 40% in ton-miles flown and to the fleet of six DC-6As which he termed "a more economical aircraft on relatively long hauls."

Last month Slick inaugurated the Sky-Van, a system of furniture moving by air through the use of large aluminum containers.

Eastern Air Lines handled 14,672,350 ton-miles of freight during the year. Frontier Airlines led the local service carriers in cargo and mail transported with 645,370 ton-miles of freight and 343,405 ton-miles of air mail. North Central Airlines led the air express field by moving 361,346 ton-miles of express during the year.

Internationally, the world's airlines passed the 1 billion ton-mile mark in freight carried for the first time. The International Civil Aviation Organization reported slightly over 1 billion ton-miles of freight were handled by the carriers last year compared to 910 million in 1955. Mail ton-miles climbed from 260 million in 1955 to 280 million in 1956.

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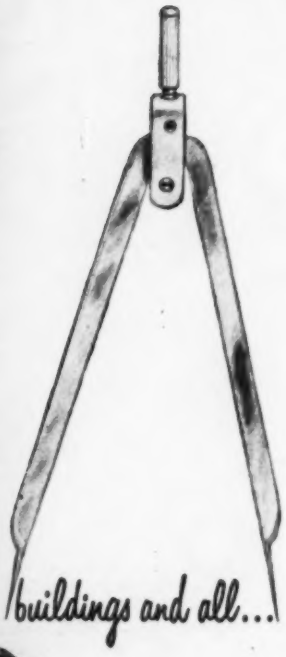
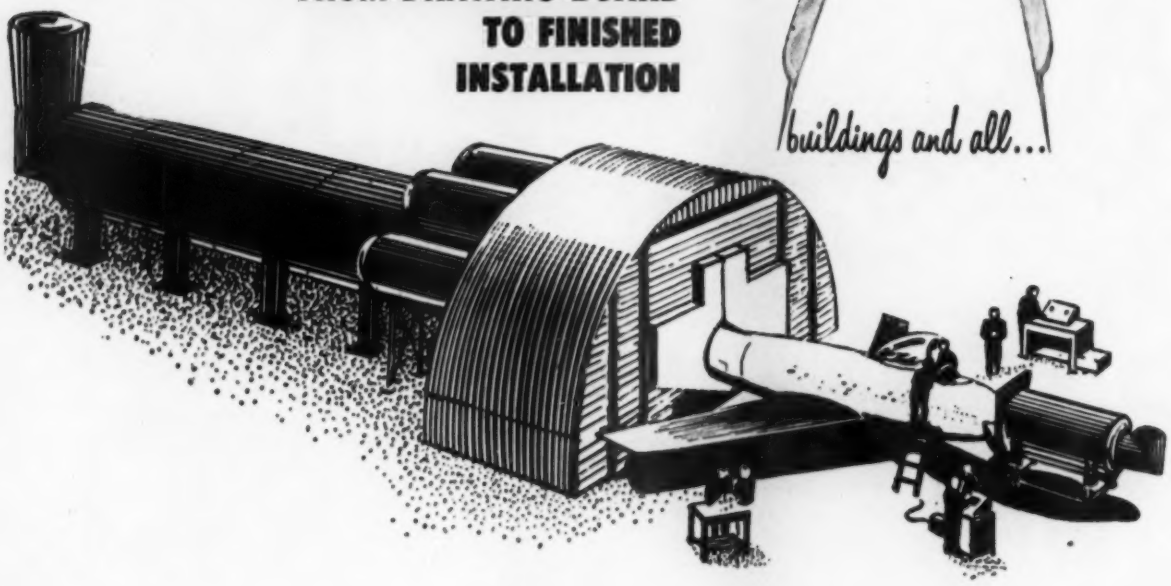


buildings and all...



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Nonsked Prospects Improve Despite Adverse Court Decision

Prospects are good for a substantial improvement in nonscheduled airline business this year despite a major setback last July that threatened to strip the carriers of their temporary classification as supplemental airlines.

Offsetting this setback were a remarkable safety record continued through 1956 from the previous year and the award of military charter contracts for international service. These brought new promise to an industry that has struggled for 10 years to attain legal recognition.

The 1956 achievements followed a Civil Aeronautics Board endorsement late in 1955 that recognized the irregulars in air transportation and all but placed legal status in their grasp.

At that time, the Board granted 45 nonscheduled airlines temporary authority to operate as supplemental carriers until the complicated Large Irregular Case was settled.

Status Unresolved

In July, however, a U. S. Court of Appeals judgment vacated the Board's decision and questioned its right to issue exemptions for supplemental operations. The ruling was a victory for the scheduled airlines.

The nonscheduled airlines have not reverted to the irregular air carrier authority under which they have operated since their inception 11 years ago, and the CAB asked the Appeals Court to stay its judgment until after the Board can reach a decision of its own.

In a separate move, the carriers have protected themselves against a denial of the CAB petition by obtaining an extension of the time allowed to request a review of the Appeals Court decision by the Supreme Court. This has allowed the nonscheduled airlines to maintain a flimsy hold on their supplemental status. Their ultimate status is not likely to be resolved until summer.

The scheduled airlines brought the case to the Appeals Court when the CAB refused to amend its original decision granting the supplemental carriers authority to operate no more than 10 flights a month between two given points. It was this 10 flight rule to which the scheduled airlines principally objected.

The scheduled airlines now ask that the status quo of the supplemental carriers be maintained until all issues are decided at one time when the Board makes a final decision in the Large Irregular Case.

In its decision, the Appeals Court did not question the CAB authority but the way the authority was granted. The Court said the CAB failed to prove that it would be an undue burden to require full certification proceedings for the supplemental carriers.

The complicated legal proceedings that threatened to retard the progress of the nonscheduled airlines did not halt their aggressive traffic expansion programs during the year. Six-month military contracts enabled some carriers to plan intelligently and project aircraft distribution, utilization, overhaul and maintenance for the first time.

An estimated 157 million ton-miles were produced during the year under these contracts which involved 3,390 Pacific flights and 1,960 Atlantic flights. Ten supplemental carriers assigned aircraft last year to DEW Line operations.

On the domestic scene, 29 carriers performed 421 operations involving one or more aircraft under military contract.

The over-all safety record for the supplemental carriers was 1.4 billion passenger revenue miles without a passenger fatality. The National Safety Council recognized the two associations for the first time last year by conferring its annual honor award on each group.

Internal Troubles

The supplemental carriers were beset with internal troubles during the year. In November, the Air Coach Transport Assn. was split when a dissident group headed by Amos Heacock and supported by United States Overseas Airways, the Trans American combine and others, seized control of the association. The coup took place at a time when the organization appeared to be making headway under the cohesive leadership of President A. J. Rome.

Earlier in the year, Slick Airways and Flying Tiger Line, having been certificated for scheduled cargo service, withdrew from the Independent Military Air Transport Assn. to join the Air Transport Assn.

Speculation was strong during the year that the CAB would refuse to renew its exemption to ACTA authorizing the association to solicit charter business for its members. Certificates were renewed to both associations for one year, however, and ACTA launched an aggressive sales program to replace the more cautious and diplomatic approach advocated by Rome. Meanwhile, Rome and seven directors had resigned from ACTA and four airlines left the organization to join and restrengthen IMATA. The carriers were General Airways, Los Angeles Air Service, Meteor Air Transport and Modern Air Transport.

Grove Webster was elected president of IMATA, and the group reaffirmed its original policies and objectives and emphasized the development of commercial charter traffic as well as military traffic. ACTA is headed by an executive committee.

Roster of membership of both associations is tentative at best since the Civil Aeronautics Board must finally rule on each member's application for supplemental status. Early this year, CAB examiners recommended that 31 of the applicants be authorized as supplemental carriers. This would leave the two groups at about equal strength. In July, CAB Counsel James L. Deegan

had recommended that 33 of the 54 applications be denied.

At the same time, Deegan proposed these criteria to determine a carrier's right to supplemental status:

- **Sufficient financial resources.**
- **Carriers guilty of any previous** major violations should be eliminated.
- **Carriers whose operating authority** has been revoked at any time should not qualify.
- **Carriers who have not been** operating in either 1955 or 1956 should not be considered.

In August, the CAB Office of Compliance asked for suspension of operating authority of four airlines in the five-airline Trans American combine for continued violation of a CAB order issued in July, 1955, ordering the non-scheduled airlines to halt operations of a frequent or regular service. The Office of Compliance charged the four airlines with operating regular service.

The airlines involved were Trans American Airways, Twentieth Century Airlines, Trans National Airlines and Hemisphere Air Transport. Trans American appealed the revocation, and the group continued to operate pending a court decision. Later in the year, the CAB revoked the operating licenses of Penisular Air Transport and Aero Finance Corp. for economic violations of the law. The two carriers also were under fire for safety violations.

Air Exchange Operations

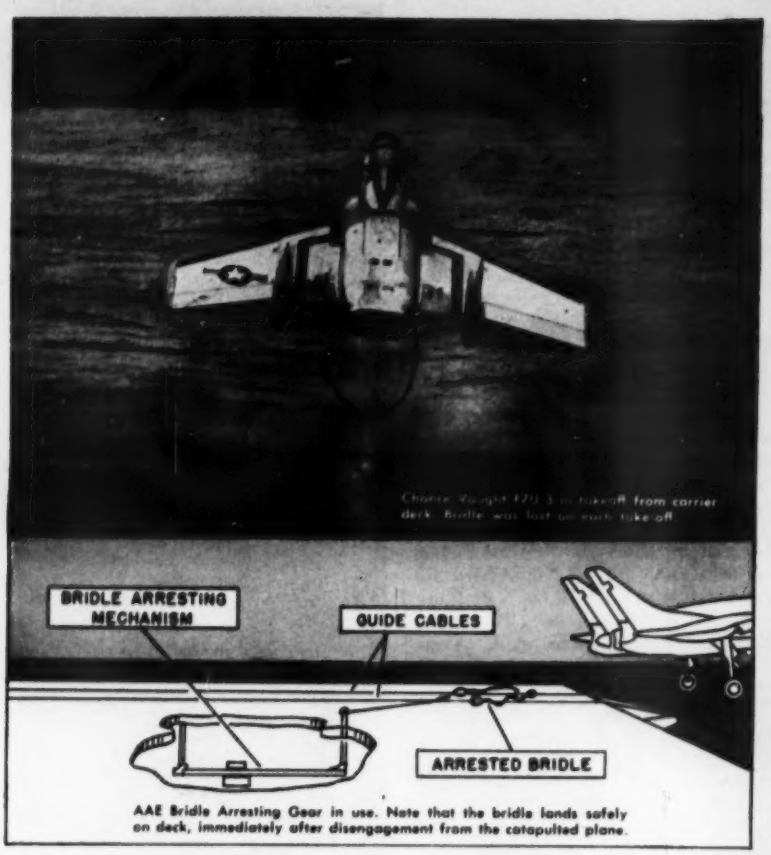
Both ACTA and IMATA are authorized to operate the air charter procurement facility known as the Air Exchange. This permits the two associations to coordinate and bid on civil and military air traffic movements on behalf of members. The two air exchanges became effective in January.

Other privileges obtained from the CAB decision at that time were:

- **Right to operate unlimited domestic** cargo and passenger charter service.
- **Authority to operate** a maximum of 10 flights in one direction between any two points for individually ticketed passengers or waybilled cargo.
- **Authority to operate charters** for cargo service on international routes.

The CAB stayed sections of its decision on international operations for White House review. Although White House approval is not necessary, the action was taken because of the effect any decision might have on international affairs. By early this month, the White House still had not rendered an opinion.

At the same time, 45 irregular carriers received interim authority to operate as supplemental airlines with the foregoing operating rights. Continental Charters, Carribean American Airlines and Economy Airlines were refused supplemental authority because they



AAE Bridle Arresting Gear in use. Note that the bridle lands safely on deck, immediately after disengagement from the catapulted plane.

Arresting a bridle...

A bridle and a supersonic jet fighter go together like a horse and bulldozer. But a bridle is used every time such aircraft carriers as the U.S.S. Forrestal launch a jet. A bridle in Navy terms is a steel cable used in connection with a steam catapult. Not long ago every time a jet took off from the deck of a carrier a bridle went into the sea. With it went $200 of the taxpayers' money or approximately $200,000 on an average training cruise.

All American Engineering believed that because bridles—and money—had always gone over the side when an aircraft was launched there was no reason why this should always be so. All American's engineers went to work on the problem and the bridle arresting gear was the result. Now bridles are saved and used again and again.

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United States Aircraft Engaged in Air Transportation

Irregular Air Carriers, Domestic and International Service*

CAA REGIONS	ACTIVE OPERATORS	Douglas					Curtiss	Lockheed		Miscellaneous	Total
		DC-6	DC-6B	DC-4	DC-3	DC-2	C-46	L-1049	L-749		
Reg. 1	4	1		2	3		6				12
Reg. 2	10				1		46		1		48
Reg. 3	2				3		4				7
Reg. 4	21		2	34	12	1	14				63
Reg. 5	3			1	2		1			1(c)	5
Reg. 6	0										0
Int'l. Reg.	5			21			3	4(b)		3(a)	31
TOTAL	44	1	2	48	21	1	74	4	1	4	186

NOTE: Data compiled from current, effective Operations Specifications—Aircraft Identification, Form 215-A. Includes operators certificated under CAR 46, in addition to CAR 42. Regional distribution of aircraft is based on location of the principal maintenance base for the particular aircraft involved.

* This does not include the irregular air carrier aircraft below 12,500 lbs.
(a) 3, SA-16A (Grumman Albatross).
(b) 3, L-1049D; 1, L-1049E.
(c) 1, B-18.

failed to file operating statistics. If the latest CAB examiners' recommendations are accepted, the number of authorized carriers would be shaved to 31 (see chart on page 145).

American Air Export and Import Co. was certificated as a scheduled cargo airline in 1956. Other cargo airlines holding scheduled certificates are Aerovias Sud Americana, Flying Tiger Line, Riddle Airlines and Slick Airways.

In February, the Board turned down a Trans American request for exemption to operate two flights daily between New York and London, Paris, Frankfurt, Rome at aircoach rates substantially lower than current fares.

The celebrated North American name case came to a climax in April when the Supreme Court refused to review the North American case and upheld a lower court ruling that granted North American Aviation an injunction restraining the airline from using the North American name. American Airlines also filed complaints, and the Supreme Court decided last month to hear the case. Meanwhile the irregular carrier switched to the name Trans American.

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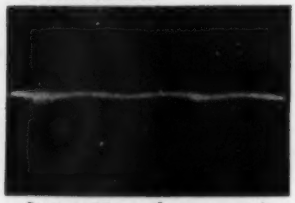
Scope pattern of receiver output with 50 microvolt MCW signal in the presence of precipitation static. Signals less than 2,000 microvolts are not readable.



Scope pattern of same receiver output with same signal input and Hoover Model 10018 inserted in the antenna circuit. Buried intelligence has been preserved by removing the interference.

Picture above shows this same signal after receiver gain has been increased about 50 times. Signals as low as 5 microvolts are readable.

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Jet Age, Growth Strain Airports, Airways

By Cecil Brownlow

Washington—Appearance of America's first commercial jet airliner scheduled late next year combined with growth of air transportation is creating a chain reaction of costs and problems for airlines, airport operators and government agencies.

To prepare airways and airports to cope with these problems, this is what is being done or must be done:

- **Admittedly-antiquated traffic control** system is undergoing a three year period of intense modernization at an estimated cost of $246 million. This still will fall short of foreseeable needs.
- **New or expanded** terminal facilities are needed to handle scheduled airline passenger traffic which the Civil Aeronautics Administration says will grow from 47 million in 1956 to 101.9 million in 1965, 129.5 million in 1970.
- **Means of ticketing and loading** passengers and baggage aboard a large jet airliner, which may carry as many as 159 persons, will be necessary without schedule and passenger-upsetting delays.
- **New ground handling techniques** and equipment must be developed and purchased.
- **Length and strength** of runways needed to support heavy jet transports —whether present runways are adequate for the job—must be decided by airport operators and airlines, once Civil Aeronautics Board establishes firm jet operating conditions.
- **Effective noise suppressors** must be provided by manufacturers to fulfill their contracts with airlines.
- **More space for maintenance** facilities capable of handling both jet and piston-engine transports may be required by airlines.

Most urgent need by everyone's standard is an air traffic control system capable of meeting the needs of a fast expanding transportation system. Air Transport Assn. estimates that flight cancellations and delays due to traffic control congestion over the present system cost the air transport industry approximately $9.4 million annually. Charles Lowen, the late CAA administrator, said cost to the airlines could go as high as $22 million by 1965 if the present system remained unchanged.

Three Year Plan

The move into the three-year plan for modernization was begun in Fiscal 1957 when Congress, on Lowen's insistence, appropriated $40 million to get a five-year plan under way.

After the mid-air collision of United and Trans World airliners over Grand Canyon last summer (AW July 9, p. 39), President Eisenhower asked for an additional $68 million to telescope the program into three years. Congress agreed to a compromise addition of $45 million for a total of $85 million.

Primary purpose of the plan is to provide the facilities and manpower needed to maintain positive control of all aircraft flying above 15,000 ft. where the commercial and military jet will be. This means improvement in three broad areas:

- **Radar.**
- **Communications.**
- **Navigation aids.**

CAA's Fiscal 1958 budget calls for a record $149 million to be spent upon navigation facilities alone.

The CAA pushed the radar program into high gear late last year when it awarded $9 million in contracts for the purchase of 23 long-range radars in the largest single order for electronics equipment ever placed by the agency.

Joseph H. Tippets, director of CAA's Office of Air Navigation Facilities, says use of long-range radar will enable the CAA to increase the instrument capacity of its system by "at least four to one."

Narrow Band

In another step to ease the traffic control burden, the CAA early this month announced that the number of civil communications channels for traffic control will be doubled through an order for 2,580 narrow band communications receivers. When installed, these receivers will permit effective reception of transmissions spaced 100 kc. apart rather than the 200 kc. now needed.

CAA Administrator James Pyle says his agency is considering quadrupling the number of channels by providing a separation of 50 kc.

Despite these orders for hardware, by far the greatest traffic control step of the year was made in September when six years of bitter wrangling between the various aviation factions was ended by an Air Coordinating Committee decision to adopt Vortac as a common federal airways navigation system (AW Sept. 10, p. 39).

Common System

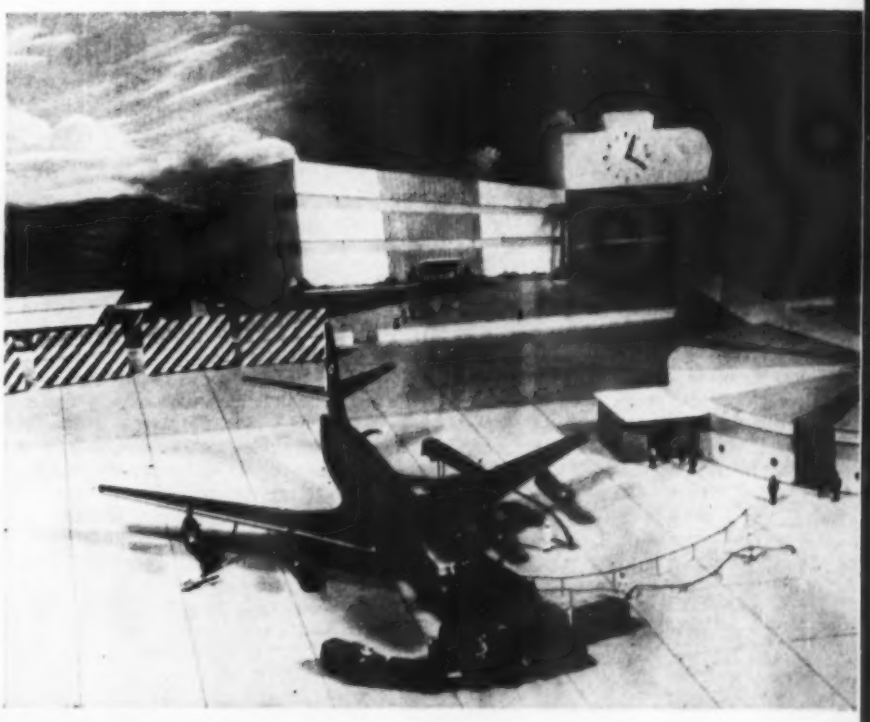
The compromise decision calls for the integration of Navy's Tacan with civil VOR and ILS. Plans provide for the installation of 295 Vortac stations by the end of 1959 and for 1,087 stations in full operation by 1965.

The air traffic control system is also hampered by what Gen. Milton W. Arnold, a vice president of the Air Transport Assn., refers to as "our vanishing airspace."

As an example, Arnold points to one block of air between Washington and Springfield, Mass., comprising 25,250 sq. mi. Of this, Arnold says, only 1,300 sq. mi. are free from some type of restriction or control.

At least one Senate subcommittee already is looking into the military practice of blocking out large areas of

MODEL OF CONVAIR 880 LOADING



airspace for its own use, with a view toward curbing it.

These restricted areas, plus obsolete and obsolescing equipment, place still another restriction upon the traffic control system whose failures are often far reaching and costly. Last June 21 is a case in point:

This particular failure, due largely to the lack of necessary equipment, came on a day when weather conditions were above limits. It began in Washington and quickly spread to every major airway in the Eastern U.S. The resultant traffic tie-up forced an estimated 30,000 passengers in the East and Midwest to cancel travel plans, delayed 4,754 American Airlines passengers in New York alone. It took another airline three days to regroup its equipment and resume operations on schedule (AW July 16, p. 26).

System Obsolescence

Sheer obsolescence of the present system means that the presently-budgeted three-year plan is no cure-all. The man named by President Eisenhower to find one is Edward P. Curtis.

Curtis, special assistant to the President for aviation facilities planning, has been charged with these major responsibilities:

- **Direct a study** of the nation's long-range requirements for aviation facilities—including airways, navigation aids, communications and airports.
- **Develop a comprehensive plan** to meet these requirements.
- **Recommend such organizational**, legislative and budgetary procedures as may be necessary for implementation.

The latter responsibility has given new impetus to a move both within and without the government for removal of the Civil Aeronautics Administration from the all-encompassing Commerce Department and for its establishment as an independent department with cabinet representation.

If this becomes a reality—and it may be recommended by Curtis whose report is due sometime this spring—the President probably will press Curtis himself to accept the cabinet post.

Eisenhower's special assistant says his report also will give airport operators "a reasonably accurate estimate of the volume and type of traffic they should provide for in the next 20 years."

Lack of any such detailed report to serve as an index to future needs is the greatest complaint of airport operators and the Airport Operators Council. Biggest sore spot at the moment: future runway needs.

Will jet transports, with their greater weight and landing speeds, be able to fit themselves into the present runway structure of American airports?

This is a much debated question, and one that won't be fully resolved until after jet transports begin actual operation. A definite clue will be provided later this year, however, when the Civil Aeronautics Board hands down its decision on the conditions for commercial jet operations. At present, the answer seems to be this:

- **Domestically,** jet transports will be able to operate into and out of the major hub terminals with a minimum of difficulty.
- **International** airports may need more concrete.

The amount of difficulty will vary from airport to airport, from season to season and, literally, from trip to trip.

Temperatures will play an important part, since jet engine efficiency decreases as temperatures rise.

Length of the route to be flown is another factor. Almost half the total weight of a jet transport loaded for an international flight will be in fuel. This figure is cut to one-third of the total weight for a coast-to-coast flight of 2,500 mi.

With their planned expansion programs, present international airports should be able to handle the heavily loaded international flights more or less on schedule, although temperature may have its effect here, too, delaying flights from a summer noon to the relative coolness of night.

Runway Cost

The speed and range of the jet transport may also make it technically and economically feasible for such hub points as Chicago and Washington to become truly international terminals. If they decide to do so, they must have more runway at a rule-of-the-thumb cost of $1 million per 1,000 ft.

As to how much runway is needed for specific flights, a preliminary study by Boeing Aircraft Co. shows that a high-speed cruise flight by its 707 transport equipped with Pratt & Whitney J57 turbojet engines would have a maximum range of 1,900 mi. if loaded for takeoff from Atlanta's effective runway length of 5,866 ft.

The same aircraft, contingent upon Atlanta observing its average temperature of 78F, could fly 2,500 mi. under long-range cruise conditions.

A 707 equipped with the more powerful Pratt & Whitney J75 could, the Boeing study shows, fly 2,800 mi. from Atlanta at high-speed cruise and 3,600 mi. at long-range cruise. Most distant large hub is San Francisco, 2,448 mi.

As helpful as such studies may be to airport operators, the Airport Operators Council says it still cannot formulate an accurate yardstick for overall runway needs because the airlines are reluctant, for competitive reasons, to disclose over just what routes they will use their jets. For the moment the council appears adamant in its stand that aircraft manufacturers tailor their designs to fit existing runway lengths.

Here, it has the strong backing of such federal agencies as the CAA and of such men as Presidential Assistant Curtis. Curtis says:

"There has been a decided tendency in the past to design and build maximum performance aircraft on the assumption that somehow airports will be built to accommodate them.

"Instead of demanding more and more concrete, the designers must make maximum use of techniques as boundary layer and jet flap control to improve the takeoff and landing characteristics of our future planes."

This may mean that the manufacturers must look to such aids for the next round of jet transports, but it doesn't alter the fact that 707s and Douglas DC-8s already are on order without jet flap or boundary layer control.

One airline representative says frankly that the situation resolves itself to this: cities that want jet transportation must provide the means for the airlines to get their jets into and out of their airports. Those who don't won't get the service.

He thinks most of them will.

There also is the problem of runway strength. Can existing runways stand the heavy takeoff and landing weights of jet transports?

Studies by Boeing and the Civil Aeronautics Administration's Technical Development Center indicate they can. The saving factor is the weight-spreading dual-tandem landing gear planned for the DC-8 and 707.

Runways at New York International, for example, can theoretically withstand the weight of 200,000 lb. from a single-wheel configuration as that on the DC-3. With a dual-tandem gear, they can support 500,000 lb.

Actual Weights

Maximum gross design weight for the 707 intercontinental version is between 280,000 and 295,000 lb.

Other dual tandem landing weights include Chicago, 252,000 lb.; Los Angeles, 315,000 lb.; San Francisco, 420,000 lb.; and Miami International, 315,000 lb.

The problem of jet noise rests primarily with the manufacturers.

Most jet transport orders contain a proviso that noise will be reduced at least to the level of present-day piston engine aircraft. New York, the nation's busiest city, has decreed that no jet transport will be allowed to land at its three major airports unless it has an effective noise suppressor.

Growing amount of money and engineering talent are going into the development of suppressors—ones that can quiet a jet engine and still provide thrust enough to power the air-

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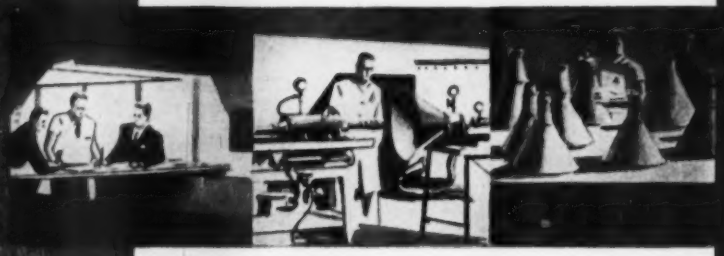

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plane. Companies and agencies working on the project include the National Advisory Committee for Aeronautics, Rolls-Royce, Boeing and Douglas.

Boeing already has flight tested one model, and an Air Transport Assn. spokesman who has followed the overall development thinks industry will provide a relatively-effective, if "crude," suppressor in time for the first jets.

Next is the problem of airport facilities.

Sir William Hildred, director general of the International Air Transport Assn., has complained that something has been missing in the coordination between those responsible for planning airport facilities and the airlines who use them (AW Sept. 17, p. 38).

This lack of coordination, Sir William says, is responsible for the ground handling chaos that exists today and adds unnecessary time to air travel.

The chaos is sure to increase in direct proportion to the growing traffic volume if better communications are not established.

Again, the Airport Operators Council complains that the airlines refuse to predict such things as ticket counter needs in time for the airports to incorporate these needs into their own planning. The airlines reply that they make their needs known as soon as they possibly can without taking undue chances of over-buying space.

Ground Handling

Along with the passenger growth in general, there will be the problem of providing enough ticket space and gates to get 150 passengers comfortably aboard a single aircraft.

Corollary to this is passenger baggage. How do you fit this much baggage into the aircraft in time for takeoff? Present suggestions include the use of conveyor belts and pre-loaded pods.

Another facilities problem revolves around the best method, or methods, to refuel a large jet transport. Most planners believe the tank truck is on the way out, that the answer will be hydrant fueling.

Trend also is toward fewer pieces of mobile equipment which, in themselves, create a block to orderly passenger flow from gate to airplane. Other jet-age ground equipment requirements include:

- **Starting equipment.**
- **Better maintenance** and test equipment.
- **Stronger towing** equipment.

In December, the airlines postponed "indefinitely" any industry-wide decision on the ground equipment to be used. One reason given was the need for practical prototype testing of the various pieces of equipment being offered by the manufacturers.

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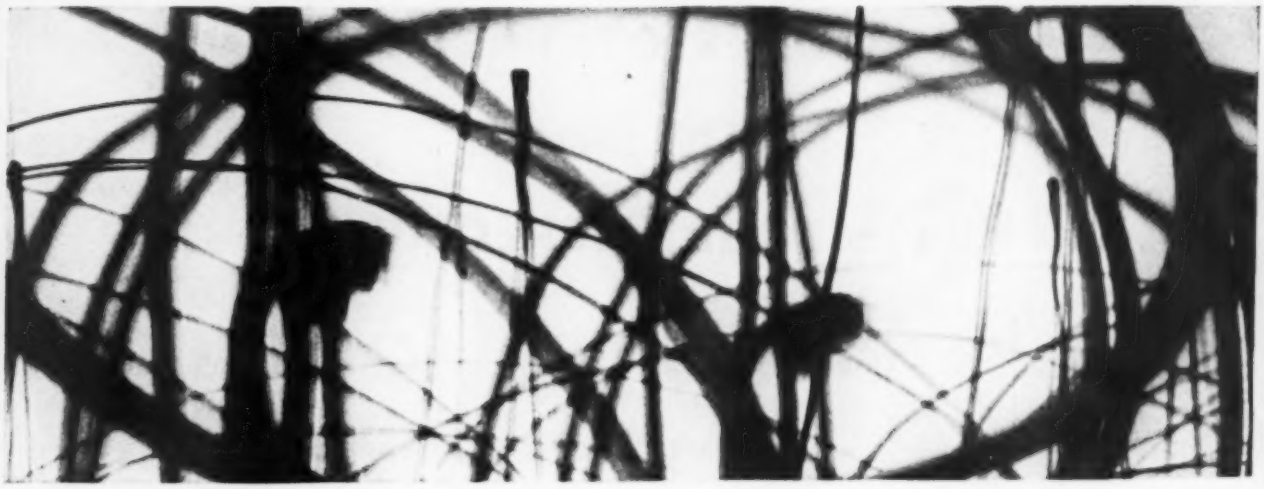
The Douglas X-3, used in heat dispersion studies.

With aircraft that top 1000 mph now in military service, the problem of *heat dispersion* gets growing attention from Douglas engineers.

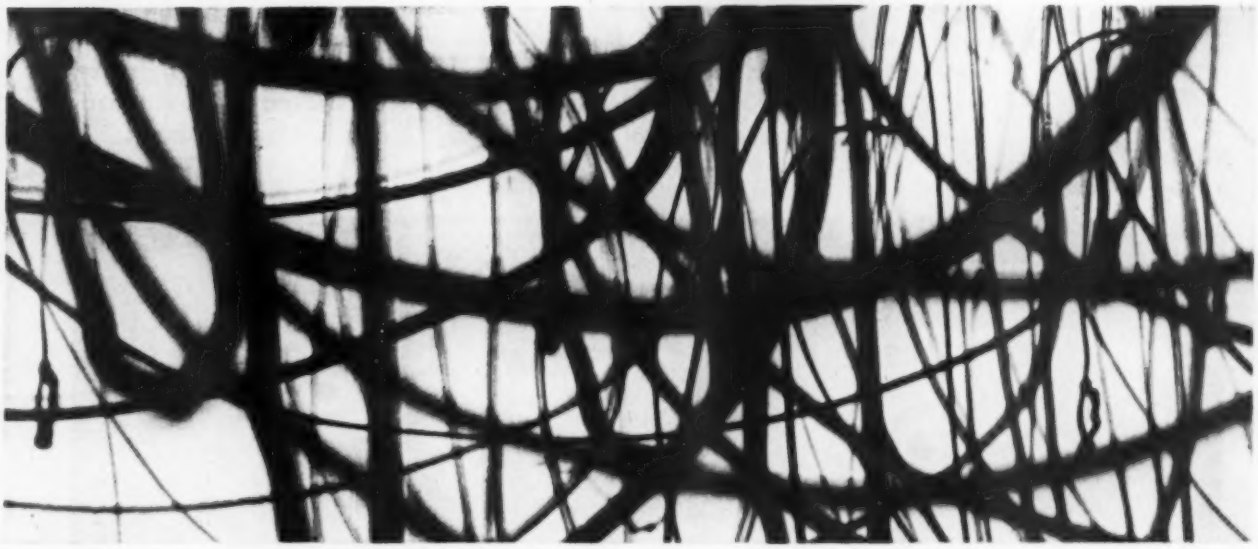
Once called the heat barrier, science now uses a more accurate term, *thermal thicket.* The faster you fly through the earth's atmospheric blanket, the further into the thicket you get . . .

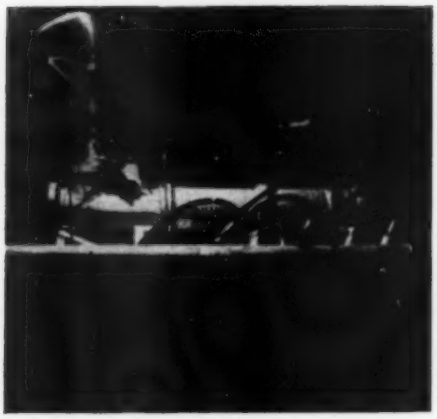
At Mach 2, twice the speed of sound, a plane's skin temperature can reach 275°F. At Mach 3 it leaps to 650°F, and at Mach 5 hardened steel wilts like lettuce . . .

Douglas is attacking this heat problem on many fronts. Air conditioners powerful enough to cool a theater were tested in the famous X-3 research plane seen at left. In current Douglas missiles, amazing advancements are being made in the design of heat-resisting materials and structures. This knowledge will speed the solution of the thermal thicket problem for piloted aircraft.



Thicket





The Douglas Aero-rotor, an instrument that blasts out high velocity gas at temperatures upward of 3000 degrees Fahrenheit, helps in research for materials to withstand high temperatures and jet velocity erosion. Other work now on the boards at Douglas ranges from designs for the practical application of atomic power to the complete design and building of intercontinental missiles — and even includes the engineering for a space platform first considered as early as 1946.

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SABENA DOUGLAS DC-7C

World Airlines Set Expansion Plans

Profits and progress of major world airlines in 1956 kept pace with the 1955 boom. Year showed substantial increases in traffic and revenues, though nations seeking to establish their own flag carriers found the road paved with deficits.

Plans for the jet era embraces route extensions and major equipment additions to scheduled air fleets. Also in the works is modernization of old and construction of new airports.

Major problem still entails negotiation of various bilateral air agreements.

Argentina

Argentine government's abolition last year of the state monopoly in civil air transport resulted in the formation of four new scheduled airlines:

● **Transcontinental S. A.,** whose charter authorizes both domestic and international flights. Overseas flights are to be made with Super Constellations to be acquired on the hire-purchase system, financed by California Eastern Aviation, Inc. and the Bank of America. For domestic flights, five CW20-Ts have been acquired. It is unlikely that this company will begin international flights during 1957. Insurance provisions for Super Constellations provide that these planes must be piloted by American pilots during the first year of their operations. Argentine law provides that no Argentine flag plane may be piloted by a foreigner.

● **ALA** (Compañia Aerotransportes del Litoral Argentino S.A.) was formed with its capital partly subscribed by the Chamber of Commerce of the city of Rosario. This line will engage in domestic flights only. The firm plans to buy Aero Commanders in the U.S., and begin services with the light twins in four to six months.

● **TACA** (Transporte Aereo Costa Atlantica) will inaugurate domestic flights along the coast, southwards from Buenos Aires, within the next six months.

● **Lineas Aereas Aeronorte,** based in Eldorado in the northern province of Misiones, has already begun services among northern cities and plans to add flights to Buenos Aires. It is currently operating with Beaver, Cessna 180 and 310 and Beech Bonanza equipment. It plans to buy two Aero Commander 680s in the U. S.

There are, in addition, 39 unscheduled air taxi services in operation most of which provide for both passengers and freight, and nine commercial air enterprises for advertising, crop dusting, etc. All of these firms have come into existence since the new air law was passed permitting the entry of private capital into what had formerly been a state monopoly.

Aerolineas Argentinas, the state line, has been transferred from the jurisdiction of the Ministry of Transport to that of the Air Ministry.

The line, which continues to operate with a large deficit, is also expanding its services. A second tourist flight to New York each week was inaugurated in late 1956, and negotiations are underway for the purchase of Super Star Constellation 1649s with which to institute first-class overseas flights. Negotiations are also going on with Air France for a reciprocal ticketing arrangement in Buenos Aires-Europe flights. These talks anticipate that Air France will do the maintenance on the Constellations.

Aerolineas Argentinas has also purchased two used Douglas DC-4s for use on domestic flights. The enterprise has proposed to the government purchase of several Fokker Friendship planes, produced by Fairchild, to fill the place left by the Douglas DC-3.

Operating expenses of $30.3 million were incurred by Aerolineas Argentinas during 1956. Operating revenues were $20.1 million; net loss, $10.2 million. Government will cover the deficit, and will invest another $8.6 million in the airline, mainly for acquisition of new aircraft.

Australia

Growth of Australian civil aviation continued undiminished in 1956. Mail-ton miles increased 8.3%; freight traffic 7.8%. Domestic carriers carried over 2,000,000 passengers, an increase of 5.7% over 1955. International passenger traffic was up 14.2%.

Australian National Airways has acquired new DC-6B planes, has no other aircraft on order. Early in 1957 it plans to replace its fleet of DC-3s. Persistent English reports that its choice will be the Handley-Page Herald have

never been confirmed in Melbourne. Its helicopter operations also will be expanded in 1957.

Trans-Australia Airlines is standardizing on Vickers Viscounts and will shortly have a fleet of 13. Its replacement for its DC-3s will be the Fokker Friendship for which five initial orders were placed. It will probably buy two Vickers Vanguards for its longer routes although de Havilland would like it to buy Comets for the trans-Australia route.

TAA may also expand helicopter operations.

Ansett Airways has ordered Convair Metropolitans and expects first delivery early in 1957. This tourist-fare operator has smartly increased its share of the Australian air transport business.

Qantas Empire Airways Ltd., in the Australian fiscal year ended June 30, 1956, showed an increase of 17.5%. This included boost of 22.5% in passenger miles flown and 14.2% in number of passengers carried. Freight tons increased 8.8% and mail tons 6.9%.

Qantas will order Boeing 707s. It probably will be first non-American carrier to have them. Qantas will streamline its services to U.K. to counteract the introduction by BOAC of Bristol Britannias. It has a large fleet of Super Constellations which it intends to use until 707s are delivered.

South African Airways, Scandinavian Airlines System, and Lufthansa are all in various stages of planning for services to and from Australia. Services directly to South America are unlikely in the near future though under review by Australian and French interests.

Austria

A drastic increase in air passengers was reported in Austria toward the end of 1956 when more than 8,000 Hungarian escapees were flown to the U. S., Canada, England and West Germany. However, overall increase in freight and postal shipments indicate a general upward trend.

The 1956 total of arriving passengers amounted to 89,100; departing passengers, 107,486. By comparison, there were 64,734 arrivals in 1955 and 65,099 departures.

During the year air freight ran to 2,548 metric tons, almost double the 1955 figure of 1,389 metric tons. Air mail handled for the year amounted to 440 metric tons, as against the 1955 figure of 334 metric tons.

Austria had 41 aircraft of all types licensed as of Dec. 31, 1956.

Belgium

Preliminary estimates indicate that Sabena carried over a half-million passengers during 1956. Return to dividend payments is not impossible. During 1955 the line showed a net profit of $380,000. A 1955 law raised its capital from about $5,940,000 to about $9,900,000, and gave it the benefit of state guarantee on loans issued to acquire new material.

During 1956 Sabena began scheduled air-freight service. During 1955 freight traffic represented 25.9% of Sabena ton-km. traffic and 13.3% of total receipts. Venture is an attempt to connect with cargo services for U. S. and Africa from Brussels Airport.

Sabena's four-times-a-day helicopter service to Paris, from Brussels, using S-58s, will begin this spring. Brussels-London service will pend line's acquisition of multi-engine helicopters.

During 1956 Sabena received 4 of 10 Douglas DC-7Cs ordered; all 12 Convair Metropolitans used in European and Middle East service; 5 of the 8 Sikorsky S-58 helicopters to replace the S-55s, which have been sold. Both DC-7C and Metropolitan are fitted with RCA radar nose. Line reportedly will lease three of its DC-7Cs through International Aircraft Leasing Co. of Wilmington, Del., for five years.

Sabena also has on order four Boeing 707-320 Stratoliners. Delivery will begin in December 1959. Peak traffic of 1958, associated with Brussels World's Fair, will be carried in DC-7C aircraft.

Brazil

Merger moves, intense competition and a newly passed subsidy law will make 1957 one of the biggest equipment buying years in Brazilian airline history. Five years ago there were 18 airlines in Brazil. There are five now and it looks as if more merger moves can be expected this year.

Last year Real-Aerovias acquired Nacional Airlines to emerge as one of the world's largest carriers with around 110 aircraft. Loide Aereo Nacional also merged with Panair do Brasil.

At the end of 1956, President Kubitschek signed a law that will empower the government's Banco do Brasil to dole out a special new subsidy of around $35 million during the next five years. Subsidy will be given out strictly for airline re-equipment programs. Amounts received will be based on payloads and kilometers flown inside Brazil on scheduled runs.

Brazilian airlines, in general, plan to spend about $62 million on new equipment to early 1959. Most of the money is going into piston aircraft but by the end of 1958 several airlines will have heavy orders for turboprops and jets. Varig plans to buy the Boeing 707-120 for its New York run.

Last year, Brazilian airlines had 285 aircraft, compared with 265 the year before. They flew 2.2 billion passenger kilometers last year compared with 1.7 billion passenger kilometers the year before. This year they expect to reach the 3-billion mark.

There were 95 million ton/kilometers of cargo flown by the Brazilian lines last year compared with 80.4 million in 1955. Some expect that air cargo for Brazil will exceed 110-million ton/kilometers for 1957 (including excess baggage and mail).

According to the most recent official financial reports, the only two lines actually making a net profit (not including subsidies) were Varig (made 88.4-million cruzeiros—about $1.4 million) and Loide Aereo (25.9 million cruzeiros). Panair was the biggest loser with 115.3 million cruzeiros net loss (before subsidy).

This year will mark the opening of direct flights between Brazil and Japan, to be inaugurated by JAL. Real Aerovias also hopes to start flights to Japan by 1958 with four new DC6-Bs.

Canada

Business was so good in 1956 for Canada's government-owned Trans-Canada Airlines, that it raised the paradoxial question of whether it was too good.

Nothing is likely to upset the preeminence of Trans-Canada domestically, but TCA felt obliged in a brief to a government economic commission to raise the subject of competition. TCA feels indiscriminate competition would hurt the competing carriers and not bring more frequent service.

U. S. diplomats in Canada expect 1957 may bring two developments:

• **Canadian Pacific Airlines,** which has attempted unsuccessfully to break its way into transcontinental service in competition with TCA, may be granted permission it has requested to fly Toronto to Lisbon, possibly adding Montreal as a pickup point only. This would give Canadian Pacific an outlet from Eastern Canada into transatlantic service.

• **Pacific Western Airlines,** which began as Canadian Pacific did, a collection of "bush" airlines, may break out of the bush pattern this year to become Canada's third major airline. Line asked early last year to begin a transcontinental no-reservation air coach service, but was refused.

As far as Canadian Pacific is concerned, obtaining an outlet from Eastern Canada to Europe is taking precedence over possible domestic competition at the moment. Eventually the carrier looks toward extending its unique X-shaped route pattern, centered at its Vancouver administrative and maintenance headquarters, around the world, via Karachi to Hong Kong.

Canadian Pacific also would like to tie in its prospective Toronto-Lisbon

route with a Lisbon-South America service, a proposal which has not generated much enthusiasm from South American governments. Another Canadian Pacific proposal, which is now played down by the airline, was to fly from Sydney, Australia, over the South Pole to South America.

Trans-Canada has its own route extensions in mind. Canada has made a couple of attempts to reopen the bilateral agreement with the U.S., the last time offering to trade Calgary for three U.S. stopping points, one of them San Francisco. This proposal got nowhere. A meeting this fall of the CAB and Canada's Air Transport Board is a possibility.

Trans-Canada has had no difficulty in meeting competition with Viscount equipment on its New York-Montreal and New York-Toronto routes, and Viscount load factors on all routes have been consistently over 80%. TCA is well on its way to an all-turbine fleet: four Douglas DC-8s and 20 Vickers Vanguards on order, 18 Viscounts in service and 20 more on order at a total cost of more than $100 million.

TCA's 1956 overall load factor was 72%. It flew approximately 2,100,000 passengers in 1956, a 25% increase over the previous year. Air freight volume increased 19%, approximately 11,815,000 ton-miles being flown. Air express ton-miles totaled 2,590,000, a 20% increase, and 8,640,000 mail ton-miles flown represented a 12% increase.

Canadian Pacific, with its parent, privately owned railway-steamship-hotel system to draw on, ordered 12 more DC-6Bs, four of which were delivered in 1956, with four more due this year and four next. It also expects the first of five Bristol Britannias on a $20 million order to be delivered this September.

Pacific Western has a fleet of 69 various types, some acquired by its purchase last year of Queen Charlotte Airlines, White Horse Flying Service and Associated Airways.

Two smaller airlines, TransAir, born of the merger of Central Northern Airways with Arctic Wings, and Maritime Central Airways, which purchased four DC-4s for its new transatlantic charter service, shared in the transport boom. They also illustrated a trend toward fewer and larger airlines in Canada.

Finland

Finnair and Karhumaki, Finland's two scheduled airlines, flew a combined total of 92,497,415 passenger-miles during 1956. Figure is slightly below that for 1955. Cargo ton-miles amounted to 696,000; mail ton-miles 194,000.

Finnair has two Convair 440s on order; Karhumaki, one.

During the year Finnair opened its Helsinki-Moscow route.

France

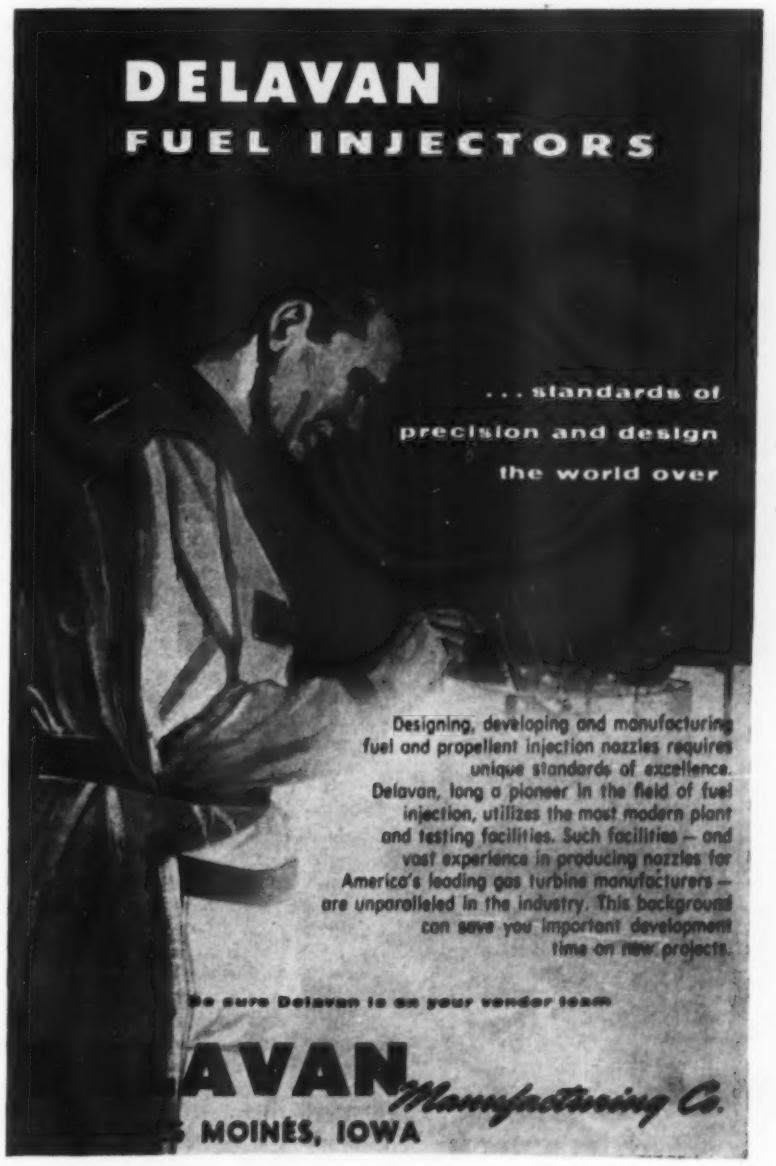
Despite a good traffic year, state-owned Air France and the two main private lines, Transports Aeriens Intercontinentaux (TAI) and Union Aeromaritime de Transport (UAT) are fighting a stiff battle to convince an unsympathetic government that they should be permitted to order all the U. S. jetliners they feel they need.

Early in 1956 Air France placed its initial jet order for 10 Boeing 707-320 Intercontinental jets. Shortly before year-end TAI ordered four long-range Douglas DC-8s and UAT ordered five. This year Air France planned to place further orders for 14 jetliners of the Boeing and Douglas transcontinental type, or the Convair 880, and firm up an earlier option on an additional eight Boeing 707-320s.

But the dollar-short French government has so far refused to release the necessary dollars. So far the only firm order which has been approved is Air France's initial bid for 10 Boeings.

Air France's order for 12 French-built Caravelles, placed over a year ago, is unaffected by the dollar problem.

During the year Air France hauled 59,430 passengers across the North Atlantic, a rise of 31% over 1955 and, the line says, the largest increase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reported by any North Atlantic carrier.

Air France is still fifth in North Atlantic importance, behind Pan American, TWA, BOAC and KLM, but the gap between it and KLM narrows.

For the whole system, company estimates indicate Air France carried 2,280,000 passengers last year, a 24% increase over 1955. Passenger-miles in 1956 were up 20% over the previous year, to 1,750,000,000. Cargo ton-miles were 49,380,000, a 17% rise, while mail-ton-miles totaled 14,770,000, up 15%. Total ton mileage flown during 1956 rose 18% over 1955 to 239,300,000. Statute miles flown increased by 10% to 46,800,000.

System-wide load factor of 71% remained unchanged. Load factor on the North Atlantic route was 71%; on European routes, 63%.

Air France's estimated 1956 gross revenue was $164,737,000, compared with $157 million reported in 1955. Expenses last year of $165,314,000 left the line with a deficit, including subsidy, of $577,000. This deficit compares with a deficit of close to $1 million reported in 1955. Government subsidy in both years remained the same, about $8 million.

At 1956 year-end the airline was operating 20 Super Constellations; 17 Constellations; 21 DC-4s; 11 Viscounts; 12 Breguet Provences; and 41 DC-3s. During the year the line added three 1049G Super Constellations, two DC-4s and three DC-3s to its fleet. During 1957 it will take delivery on three more 1049Gs and eight 1649A Super Star Constellations, the latter to be delivered between June and September.

Both TAI and UAT showed slight traffic gains over 1955, as did the third and smallest private carrier, Air Algeria. Last year was the first 12-month period under the so-called five year "cooperation agreement" between Air France and French private lines which divides up French Union traffic.

At least one private line is unhappy over the operation of the agreement, claiming it works to the advantage of the State-run line and pretty well prohibits major expansion among the private lines.

TAI, which under the cooperation agreement has exclusive rights among French carriers to routes beyond Saigon to Australasia, opened this route early in 1956. Service was extended to Darwin and to Noumea, New Caledonia. This year TAI is also serving Auckland, New Zealand.

TAI's ton-kilometers in 1956 rose to over 36 million from 35.5 million in 1955. The line carried 53,185 passengers last year compared with 52,161 in 1955. Company expects to take delivery this year on two DC-7Cs which it will operate on its Far East route to Auckland.

UAT more or less held its 1955 traffic totals during 1956, doing this by increasing its business in Africa to offset its losses in Indo-China. The line, the largest of the private carriers, hauled 125,000 passengers 45 million passenger-kilometers in 1956. UAT, like TAI, relies mainly on DC-4s and DC-6Bs.

Germany

Lufthansa closed 1956 with $4.7 million deficit which was made up in the form of a state subsidy. Expenses for the year ran to about $23.5 million while operating revenues came to only about $18.8 million.

During the year the carrier offered 558,621,000 seat/kilometers, handled only 289,248,000 passenger-kilometers. This amounts to a load factor of 52%.

While 70,096,000 ton/kilometers were available, only 33,803,000 ton/kilometers were flown, or a load factor of 48.2%. In 1956 1,000 tons of mail and 1,900 tons of freight were carried.

During 1956, four Super Constellation 1049As were added to the fleet, as well as two Twin Bonanzas and eight

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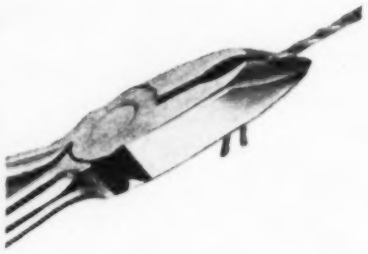

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Chipmunks for training purposes.

Future equipment plans include: two Convair 440s and four Super Constellation 1649As in 1957. These planes will be followed in 1958-1959 by seven Viscount 814Ds and in 1960-1961 by four Boeing 707s.

The year 1956 saw fairly rapid expansion of Lufthansa's services. A second North American run, via Canada to Chicago, was started. A South America run to Buenos Aires commenced operations, and the Near East was added with flights to Teheran. A sales organization was built up that included offices in 32 cities, including 16 offices abroad.

During the spring of 1957 flights to Zurich and Vienna will be started and the two weekly flights to South America will be increased to three. Damascus and Montevideo will be added to present routes.

Great Britain

British airlines turned the corner into 1957 looking a little more cheerful than a year ago. British Overseas Airways Corp. has taken a good step forward from a patchwork assortment of planes to a balanced competitive modern fleet. British European Airways—largely through its continued reliance on the Viscount—appears to have held on to its share of the markets, and the independent operators, with more variables to juggle, have added to their margins.

Here are the provisional figures for the calendar year 1956, ending December 31:

• **BOAC**: 1,115,642,302 passenger-miles flown (up 12.5%), 31,384,973 short ton-miles of cargo handled (up 13.5%), 20,036,376 short ton-miles of mail handled (up 9.5%). The overall load factor was 63.2% (up 1.5%), passenger load factor 65.1% (up 2.9%).

BOAC estimates its total operating revenue for calendar 1956 as $124,959,458; its operating costs, $120,741,434. 4.4% higher than for the 1955 fiscal year.

Net surplus is reckoned as the same as for Fiscal 1955: $329,650.

During the year, BOAC accepted six of the DC-7Cs on order from Douglas. Three more arrived in January, 1957, with the 10th and final due on April 16. Bristol Aircraft also delivered six Britannia 102s of a total order of 15, with three more slated for February, four in March, one in April and one in May. The first of 18 longer range Britannia 312s are scheduled to be handed over in the next few months, the 302 having been eliminated entirely from the BOAC order.

Beyond that, in pure jets, de Havilland has promised initial deliveries on 19 Comet 4s in 1958; the Boeing

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707s will start their arrival in 1960.

On Feb. 1, the Britannia 102s went into service from London to Johannesburg, South Africa. On Mar. 2, the run will be extended to Sydney, Australia.

In April, BOAC begins a new DC-7C service between London and San Francisco with one stop at New York. At San Francisco, BOAC will link with Qantas' transpacific routes, resulting in a complete commonwealth round-the-world air service. The DC-7C began BOAC service on a non-stop run to New York on Jan. 1.

Still under consideration is a plan to resume service to South America.

The Suez fighting and the rupture in relations with Egypt means abandoning, at least temporarily, the Cairo and Beirut airports, and setting up facilities in Istanbul.

• BEA: 794,780,818 passenger miles flown (up 15.5%); 8,840,455 short ton-miles of cargo handled (up 26.9%); 3,592,952 short ton-miles of mail handled (up 2.2%). The overall load factor was 63.4% (up 0.2%); the passenger load factor 69.3% (down 0.1%). BEA declined to make any estimate of revenue, expenses or surplus/deficit. The net surplus for fiscal 1955 was $1,690,119 on a total operating revenue of $60,478,583.

BEA made only two minor additions to its fleet during the 1956 calendar year: one Viscount 701-A and one de Havilland Heron. However, on Jan. 7 the first of the 24 longer range Viscount 802s was delivered. This will be followed by 14 Viscount 806s in 1958 and 20 Vanguard 905s in 1959. BEA also holds options for seven Viscount 801s and 12 Viscount 840s.

Missing link in the BEA equipment picture is a medium-small jet. Bristol Aircraft is known to have offered a proposal. Initial BEA order may be for as few as six jets.

During 1956, BEA opened new routes to Bergen, Norway and Gothenburg, Sweden. The question of flying into Moscow is still unsettled. Delay is political, not technical.

The company suspended scheduled services with its five helicopters, putting them on a straight charter basis. BEA feels that continuing a scheduled service is simply too expensive.

In order to accommodate its new Viscounts, BEA has scheduled an $11 million expansion of its engineering base at London Airport.

This base is now valued at about $8.4 million. It also acquired a 25% share in the Jersey Airlines Development Corporation, Ltd., and reduced its holding from 40% to 10% in Ireland's Aer Lingus.

As part of this stock reduction agreement, BEA will start flying to Dublin from London, Manchester and Birmingham in April.

For the independent air operators, the chief complaint is that the government insists on limiting trooping contracts to one year. Arrangement doesn't leave much room for equipment planning.

In 1956 the independents, on scheduled operations, flew 140,200,000 passenger miles (up 9.0%); handled 20,740,000 short ton-miles of cargo (up 71.0%). On non-scheduled services, the independents logged 649,593,080 passenger miles (up 35.9%) and handled 29,981,000 short ton-miles of cargo (up 50.2%).

There are 21 members of the British Independent Air Transport Assn. Their estimated total operating revenues on scheduled operations were about $12 million and on non-scheduled operations about $28 million. Profit would be 2-3%.

Biggest customer for the independents continued to be the government, accounting for 65% of the ton miles flown. Scheduled flights accounted for 25% and civil charter, 10%.

No direct government subsidies were given to any of the lines—BOAC, BEA or the independents. And at least for the time being, talk of merger between BOAC and BEA has subsided.

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Holland

KLM Royal Dutch Airlines showed an increase in all phases of operation during 1956. Line has received no subsidies since the war, except for year 1949. Firm has paid dividends during last few years; that for 1955 was 6%.

Total operating revenue of KLM for 1956 was near $104 million level, as against about $90.4 million in 1955. Number of passengers carried last year was 820,000, compared with 725,000 the year before. Freight ton kilometers was 63,500,000, an increase of 16.6%, and mail ton kilometers was 9,750,000, a jump of 7.5%. Passenger kilometers was 1,893,000,000, 12.9% ahead of 1955.

During 1956 six Lockheed Constellation L-1049Gs were added to the fleet, which now consists of 83 units.

KLM has following aircraft on order: for 1957 delivery, 10 Douglas DC-7Cs and 9 Vickers Viscount 803s; for 1958, 2 Fokker Friendship F-27s; for 1959, 12 Lockheed Electra L-188s; for 1960, 8 Douglas DC-8s.

India

Russian attempts to cash in on India's program to buy modern equipment for civilian purposes highlighted the Indian aviation picture in 1956. Moscow's efforts to sell the Indian Airlines Corporation (IAC) a fleet of Ilyushin 14s was blocked by Air India International's (AII) Chairman J. R. D. Tata on the grounds that Ilyushins were unsuitable for the tropics.

Moscow and Delhi did conclude an agreement to exchange traffic at Kabul in order to make the rising tourist trade between the two capitals inexpensive. This, incidentally, has brought IAC and AII—two Indian state-owned corporations—into incongruous competition. A direct Delhi-Moscow service still is in the discussion stage in Delhi.

IAC has placed orders for 10 Viscounts, scheduled to arrive in July, while AII, which in 1956 received three 1049-G Super Constellations to augment its fleet, now has concluded an agreement to place orders for three Boeing 707s at an estimated cost of around $25 million. The purchase is financed by private loans in the U.S. to be supplemented, if necessary, by the World Bank.

AII expects the Boeings by 1960, by which time India hopes to have a direct air link with the U.S.

Parliamentary Estimates Committee has questioned IAC for continuing to operate uneconomic routes, although the 1953 nationalization was undertaken to make air traffic more "economic." In 1955-56, IAC operated 43 scheduled routes. On two of these it sustained a loss of 70% and on another seven a loss of 30%. Consequently, its 1956

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balance sheet records a loss of around $2.5 million.

In 1957, it is expected the operating deficit will mount to around $4.3 million, attributed by corporation officials to increases in the wage bill, higher consumption of aviation fuel resulting from the operation of more night services and higher maintenance costs. Currently, Vikings and Dakotas operate on trunk routes and Herons on feeder routes. The Vikings are to be replaced by Viscounts this year and the over-age Dakota fleet progressively used for freight.

AH started new services in 1956 linking Singapore to Bombay via Madras, Calcutta to Tokyo via Hong Kong and more recently, Bombay to Sydney, Australia. Operating profits for 1955-56 dropped to $137,000 from $706,650 the previous year. Its pilots and commanders still are trained by Lockheed and KLM.

For the year 1955-56 AH carried 62,100 passengers, 2,772,000 lb. of cargo and 975,000 lb. of mail. For the same period IAC carried 500,363 passengers, 53,856 tons of cargo and 4,997 tons of mail.

Israel

Operating with a fleet of four Constellations, El Al, during 1956, linked Lod with Athens, Istanbul, Rome, Zurich, Vienna, Brussels, Paris, London, New York and Johannesburg.

Company has ordered three long-range Bristol Britannia 310s, scheduled for delivery this summer.

An important achievement during 1956 was the resumption of the Johannesburg flights. During the critical Sinai campaign in November, when most airlines discontinued Israel flights, El Al demonstrated its importance as a vital link with the West and its ability to maintain this link by doubling its frequency to Europe from the usual 19 to 41 flights in 10 days.

El Al receives no subsidies, but is entirely dependent on government loans for expansion purposes. Government's decision on future equipment and general policy will be taken soon when it will be decided whether a fourth Britannia will be purchased. However, it is stated that the U.S. flights will not be discontinued.

Italy

Both LAI and Alitalia, Italy's major airlines, developed considerably in 1956. Compared with 1955, LAI showed gains of 5% in mileage flown, 18.3% for passengers and 14% for mail and cargo. Alitalia showed jump of 20% in distance flown, passengers and ton-miles. At the end of 1955 revenue of both lines amounted to about $20 mil-

lion. Net profit of Alitalia ran to $200,000; that of LAI, $98,000.

Predictions are that Alitalia will close with a profit for 1956; LAI will show loss due to pilots' strike and loss of aircraft in November-December. Both firms were subsidized with $800,000 each last year. Indirect aids for 1956-57 will total $6 million.

During 1956 LAI raised its capital from $2.5 to $8 million; Alitalia from $3.2 to $7 million. Holding of BEA and BOAC in Alitalia fell to 30%; holding of TWA in LAI dropped to 30.9%.

Both lines hold equal shares in new helicopter line, ELI, along with Fiat. Government will grant regular subsidy to new line, which is expected to start regular service at the end of 1956. Line is expected to utilize S-58s in its nationwide service.

LAI has on order six Viscounts and four Super Star Constellations. Alitalia is waiting two Metropolitans. Delivery of four DC-7Cs will begin the end of this year. LAI is considering ordering turboprops while Alitalia is thinking of turbojets of DC-8 pattern.

Japan

Japan Air Lines in 1957 will embark on a 10-year plan aimed at expanding its present routes to a network circling the globe. This spring trans-Pacific flights will be increased to five weekly. DC-7 service will begin early in 1958. During 1959 JAL's DC-7C fleet will be increased from four to six; during 1960 four DC-8s will be added.

By 1965, line expects to link Tokyo, Peking, Moscow, London, New York, Los Angeles, Seattle and San Francisco. Thirty-three airplanes will be used.

Airline presently has nine DC-4s, used domestically; five DC-6Bs, used internationally. This year one DC-4, one DC-6B and one DC-7C will be added to the fleet. Three additional DC-7Cs will be acquired early in 1958.

Export-Import Bank will advance to Douglas Aircraft $7.5 million of the $13.5 million cost of the four DC-7Cs to assist it in the sale. Bank has also given Douglas $16.5 million credit to facilitate JAL's purchase of DC-8 jets.

During 1956 JAL carried 360,266 passengers 255,185,749 passenger-miles over its domestic and international routes. Line's operating revenue was $18,485,352; operating expenses were $17,082,400. Operating profit was $1,402,952. Figures cover period from October, 1955 through September, 1956.

This year an airline will be formed with merger of Japan Helicopter & Airplane Transport Co. and Far Eastern Airlines, two small domestic lines. Agreement will be formalized next fall. Each company will invest $833,000.

Mexico

Eleven foreign carriers and 21 domestic lines in 1956 operations in Mexico had these results (1955 figures in parenthesis): flew 39,538,939 mi. (37,233,000); 214,230 hr.; (203,751), 81,885 flights (65,003) and hauled 1,566,259 passengers (1,305,807) 971,522,328 passenger-miles (848,443,565); 7,004,351 lb. of mail (7,453,349), 44,909,245 lb. of freight and packages (30,052,062), 59,859,300 lb. and air express (56,474,018) and 48,494,004 lb. of baggage (46,018,148).

The 1956 figures are estimates. Air France continued to enjoy a monopoly between New York and Mexico City.

Aerovias Guest, legally a Mexican company although owned by United States capital began twice-weekly service to Windsor, Canada. This is in addition to its daily flights to Miami and its twice weekly flights to Panama.

Compania Mexicana de Aviacion, the largest Mexican carrier, continued to enjoy its monopoly of daily non-stop and daily coach service to Los Angeles. CMA, 40% owned by Pan American World Airways, operates also to Havana and 27 points in Mexico.

Aeronaves de Mexico, about 16%

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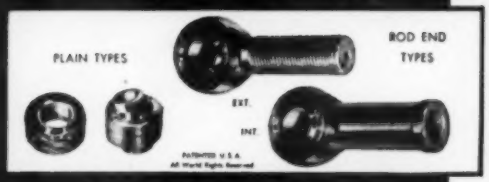

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owned by PanAm, found tourist traffic so heavy on the prize domestic route —Mexico City to Acapulco—that it often had to increase its flights to more than 30 daily. Aeronaves has leased two Constellations from PanAm and is negotiating for two Bristol Britannias.

CMA has purchased four DC-7Cs for March delivery which it will use initially on its Los Angeles run.

Philippines

During 1956 Philippine Air Lines advanced development of its main feeder line down the archipelago by opening several new fields for its Otter aircraft. Program calls for a number of collecting points along a southern route to Mindanao, using Otters.

For the fiscal year ended June, 1956, PAL's domestic scheduled traffic included 337,689 revenue passengers carried, along with 14,725,641 lb. of cargo and 869,806 lb. of mail. Revenue passenger-miles were 69,956,904.

Scandinavia

Scandinavian Airlines System's net profit after ordinary and supplementary depreciation in 1956 totaled just over $2 million for the fiscal year ended Sept. 30. Profit exceeded that of the previous 12-month period by $400,000. No subsidies were received.

Gross revenues totaled $74.2 million, including traffic receipts after deduction of commissions of $71.3 million, as against $64 million and $61.3 million respectively for the previous year. Costs rose from $62.4 million to $72.2 million.

Production capacity increased from 241 million ton-kilometers to 275 million ton-kilometers, the number of ton-kilometers sold from 124 million to 144 million. SAS carried 1,179,000 passengers against 931,000 in 1954-55, while cargo increased from 10,700 tons to 11,600 tons and mail from 4,400 tons to 4,900 tons.

At the end of 1956 the SAS fleet of aircraft numbered 8 DC-7Cs, 14 DC-6Bs, 12 DC-6s, 11 Convair Metropolitans, 8 Saab Scandias and 10 DC-3s. Of these, all the DC-7Cs and Metropolitans were added during 1956, while four DC-4s were sold to Britain, France and Japan.

There are six DC-7Cs and five Metropolitans on order for delivery in 1957. Seven DC-8s, with option for a further three, were ordered in December, 1955, at a reported value of about $50 million. Delivery is scheduled to begin early in 1960.

Only new SAS order for aircraft placed in 1956 was that for the five Metropolitans to be delivered this year.

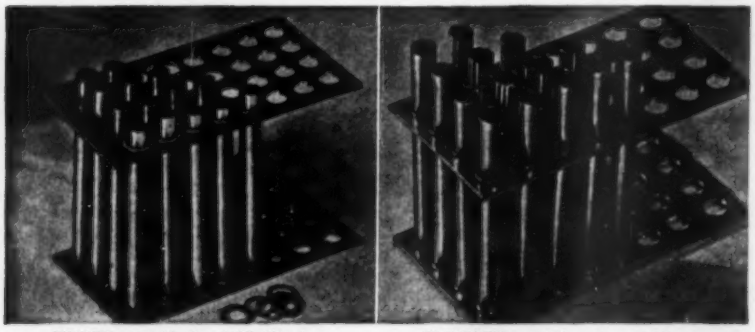
On Sept. 1, 1956, line signed an $800,000 contract with Link Aviation Inc. for a DC-8 jet flight simulator. Company will be the first European airline to get this device. Delivery will probably take place in 1959.

SAS activities in 1957 will feature the opening of its DC-7C Scandinavia-Japan polar route on Feb. 24. The biweekly service, with Anchorage, Alaska, as the only intermediate stop on the Spitzbergen-geographical North Pole-Aleutians routing, will cut travel time to 30 hr., compared with 52 for the Middle East-India route, using DC-6Bs.

The only major new service started by SAS in 1956 was the Stockholm-Riga-Moscow line, opened on May 9. SAS and Aeroflot run four weekly flights each.

With SAS predominating in scheduled domestic air service, too, little new progress is reported for Sweden's small air companies, Airtaco and Svensk Flygtjänst. As usual, the former was mainly engaged in newspaper distribution, the latter in towing targets.

Stockholm's planned new international airport may be located at Ska-Edeby, 15 mi. west of downtown Stockholm. Requiring direct investments of $34.6 million, airport could be enlarged to accommodate DC-8 jet airliners early in 1960.



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South Africa

In 1956 South African Airways put into service on the Johannesburg-London route three DC-7Bs. The state-owned airline, which receives no subsidy, had 1956 operating revenues totaling $18 million. Operating expenses were about $15 million. Profit came to $3 million.

Traffic was as follows: passenger-miles, 213,036,476; ton-miles, 2,214,230 (cargo) and 2,872,004 (mail). SAA operated at 60% loading. Passenger traffic increased by 16.5% compared with 1955.

Spain

Spain's two government controlled airlines, Aviaco and Iberia, have been joined by a third line, Trabajos Aereos y Enlaces S.A. (TAE), a domestic feeder airline which will begin operations in March, 1957.

Aviaco, which flies domestic and international routes, handled 226,104 passengers in 1956. Cargo totaled 804,396 kg.; mail, 881,123 kg. Fleet consists of six Bristols and seven Languedocs, used domestically. Line has eight de Havilland Herons on order.

In 1956 Iberia reported 24,116 flights carrying 591,000 passengers. There were 612 transatlantic flights carrying 7,322 passengers. Operating revenues were $630,411; operating expenses $556,801; profits, $73,610. Figures are for first 11 months of 1956.

Iberia's fleet consists of 15 DC-3s, 6 DC-4s and 3 Super Constellations. On order for 1957 delivery are two Super-G Constellations, and five Convair 440 Metropolitans. Iberia is subsidized by the government, through Instituto Nacional de Industrias.

TAE will begin schedules with initial fleet of eight aircraft: five Twin Pioneer 16-passenger airplanes manufactured by Scottish Aviation Co., Ltd., and three 12-passenger Presidents produced by Hunting Percival Co. Ltd. Future plans include foreign schedules to Biarritz, Paris, London and Lisbon.

Switzerland

Swissair Transport Company, Ltd., showed an upswing in all categories of air traffic during 1956. Tons/km. passengers utilized was 45,914,628 as compared with 38,380,953 the previous year. Tons/km. cargo utilized was 11,852,095, as against 9,077,015 in the previous year.

Company's 1955 profit was $367,600. Share capital was increased in 1955 from $3,263,400 to $9,790,000.

Swissair has on order three Douglas DC-8s; two for 1960 delivery, the third for 1961.

Firm also is testing Scottish Aviation Ltd. Twin Pioneer for its short-haul domestic runs.

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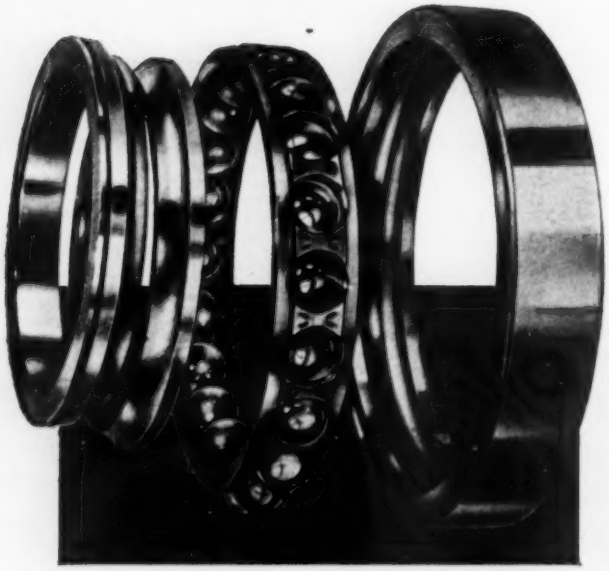

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L26	5.1181	7.8740	1.280*
L28	5.5118	8.6614	1.574*
L30	5.9055	8.5060	1.235*
L32	6.2992	9.4488	1.338
L34	6.6929	10.6299	1.815*
207	1.3780	2.8346	.669
209	1.7717	3.3465	.938*
212	2.3622	4.3307	.866
213	2.5591	4.7244	.905
214	2.7559	5.1181	1.023
215	2.9528	5.1181	1.181*
216	3.1496	5.5118	1.023
219	3.7402	6.6929	1.259
220	3.9353	7.0886	1.385*
222	4.3307	7.8740	1.771*
224	4.7244	8.4646	1.850*
228	5.5118	9.4488	2.007*
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ENGINEERING

Flow study using smoke plume in old workings used in new [illegible]

Facilities Multiply to Test Supersonic

By J. S. Butz, Jr.

Aerodynamic heating and supersonic stability problems are barriers to increasing flight speeds beyond those of today's operational aircraft; for this reason, research and development continues to concentrate heavily on these two areas.

Already broad, the research program is expanding and now includes studies to provide explanation of basic hypersonic and superaerodynamic phenomena.

Ability to stabilize (both statically and dynamically about three axes) long, narrow, and dense bodies supported by easily stalled low aspect ratio lifting surfaces, from sea level to 70,000 ft. at speeds from 100 mph. to Mach 2, must still be classified as an art.

It is an art that aerodynamicists have mastered only with the aid of avionics which provides the rapid control response necessary to overcome unstable motions almost before they originate. Such control is beyond the capability of any human pilot.

Tiny strain-gage balance, to record aerodynamic forces and moments, is shown being fitted into base of NACA model for tunnel testing at high supersonic speeds. Minute resistance thermometers and quartz gages provide surface temperature and pressure data from the same size model.

Like all problems requiring primarily empirical answers, its solution requires continuous testing.

This search for stable configurations will continue to produce strange, cut-up wing planforms, tri-form tails, ventral surfaces, dioop snoots, and other yet unnamed configurations.

Aerodynamic Heating

One of the most serious problems restricting higher speeds in manned aircraft as well as design of a workable intercontinental ballistic missile is the high surface temperature generated around Mach 3 and above.

Military aircraft in the next five or six years will presumably reach these speeds so designers today are trying to find efficient means of keeping surface temperatures low enough to insure structural dependability. With its vastly greater speed, the ICBM has the problem of surviving re-entry to the atmosphere to get its warhead to the target intact.

First solution for aircraft is increasing the skin thickness and raising the thermal capacity of the structure. This will lower equilibrium temperatures at speeds when heating becomes serious.

Elaborate Studies

However, it will probably not be satisfactory above Mach 3. The government is financing elaborate studies to determine the feasibility of cooling by:

- **Coating outer skin** with materials which melt at structurally safe temperatures thereby keeping the skin at their melting temperature.
- **Insulating outer structure** with material of low thermal conductivity and using an internal cooling agent.
- **Transpiration of gas** through porous skin to lower the temperature of the boundary layer.
- **Heat reflection** from the skin. The problem is far from solved, but scientific opinion is that a workable system is possible.

Drag Reduction Bonus

Complicating the role of the structures test engineer and his equipment is the allied problem of testing at elevated temperatures so as to define the targets for the cooling system.

One beneficial byproduct of an adequate skin cooling system will be a drag reduction of possibly 25% at Mach 3. This would result from the cooling of the boundary layer, which would delay transition and reduce the skin friction drag.

Delivering an adequate mass of air

Hurdles

at high pressure to the compressor face of the turbojet engines which propel today's supersonic craft is another largely empirical matter. Over 100 configurations of engine inlet ducts, for example, were tested for one of the Century Series fighters now flying. Many private firms and governmental facilities are engaged in these investigations, and reliable variable geometry inlets are now feasible to maintain engine efficiency and thrust with varying Mach number and shock wave patterns.

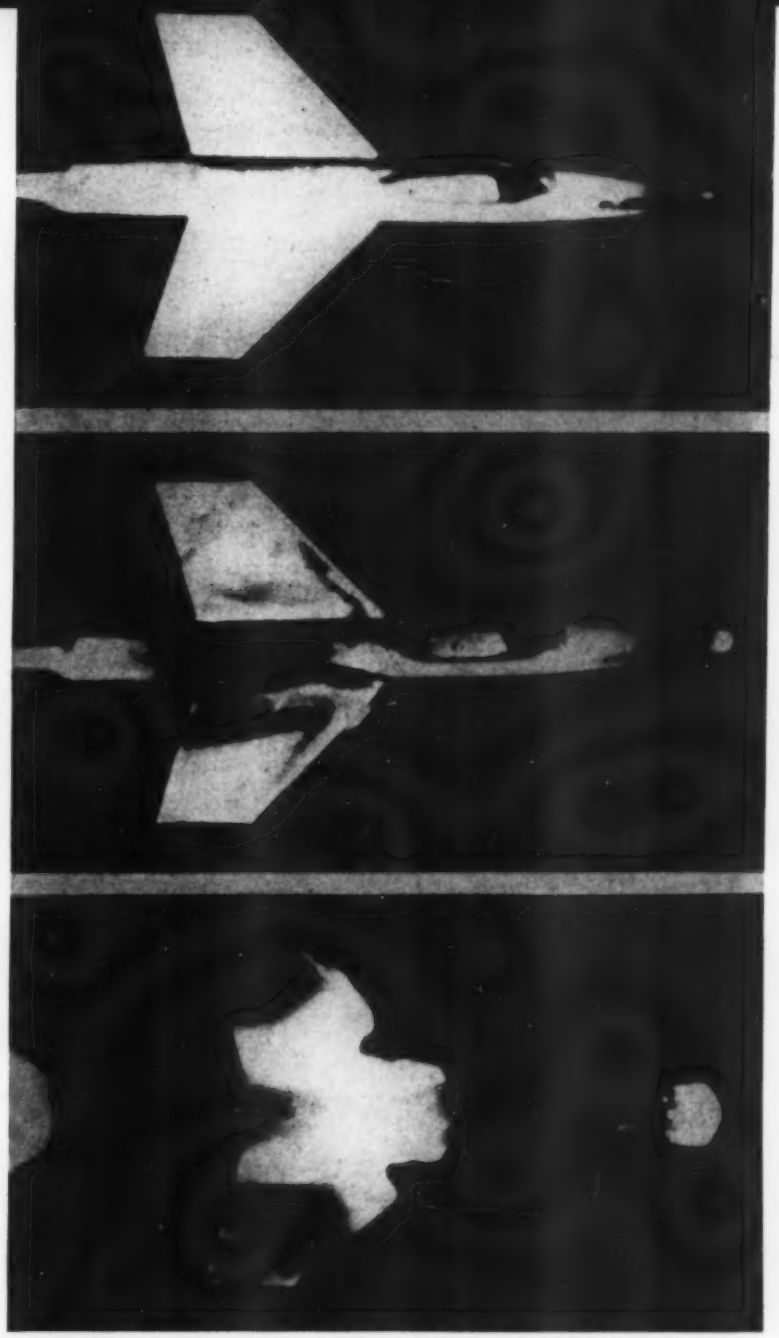
Each new aircraft presents its own peculiar problems, but sound basic design data has been made available from the research of the last few years.

New Research Areas

Study of hypersonic flow—the last largely unknown regime of aerodynamics—and superaerodynamics (science of low density flow), in which a vehicle travels in a medium of isolated molecules rather than a gas continuum, are receiving a major research effort under the impetus of the missile programs. New test apparatus is vital to this research, for theory in these fields is open to argument and far from rigid. Basic data necessary for competent design is largely unavailable.

Hypersonic flow may be compared to transonic, in that these are the only two speed ranges in aerodynamics in which the gas flow equations are non-linear. Thus more than usual reliance must be placed on test data.

Superaerodynamics involves a completely different type of flow. The boundary layer of static air on the body surface ceases to exist, and the distance between air molecules is a large percentage of the vehicle length and may even exceed it. Predicting stability and performance of a vehicle in this type of flight is enormously complicated and no verified theory exists for it.



STEEL MODEL (top, before test), in simulated 4,500 mph. flight at 50,000 ft., begins to glow at wing roots and nose (center), after .9 sec. running time, reaches incandescence and begins to erode away after 4 sec. (lower).

Hypersonic Facilities

Hypersonic investigation is more advanced. New government and private test facilities applicable to this regime become operational almost monthly. Heating studies are the primary purpose of most of the testing, but ingenious means are now being used to obtain force and pressure data from tiny models (approximately 1 in. diameter) in intermittent tunnels which can maintain test conditions for only a millisecond or so. Existing and proposed test apparatus:

• **Shock tube,** a long tube through which high pressure air is suddenly forced, creating a shock wave. The air ahead of this shock wave is compressed and heated to temperatures approaching 15,000F. Final temperature is proportional to the length of the tube.

• **Shock tunnel,** which produces more stable test conditions for longer periods. It is a shock tube or other device capable of producing a high energy shock with a supersonic nozzle between it and the test section. The nozzle expands the gas, lowering its temperature, and consequently the speed of sound which allows higher test Mach numbers for an installation of given power. Most advanced tunnel of this type, being built at the Cornell Aeronautical Laboratory, will allow testing at approximately 9,000F for 15 sec. periods.

It utilizes a number of shock tubes to maintain flow conditions for this length of time.

• **Free-flight models.** Being much larger than wind tunnel models for a given

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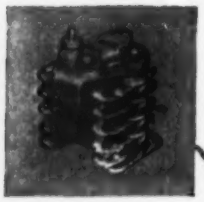

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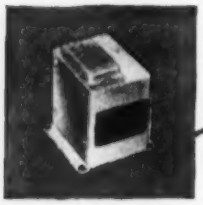

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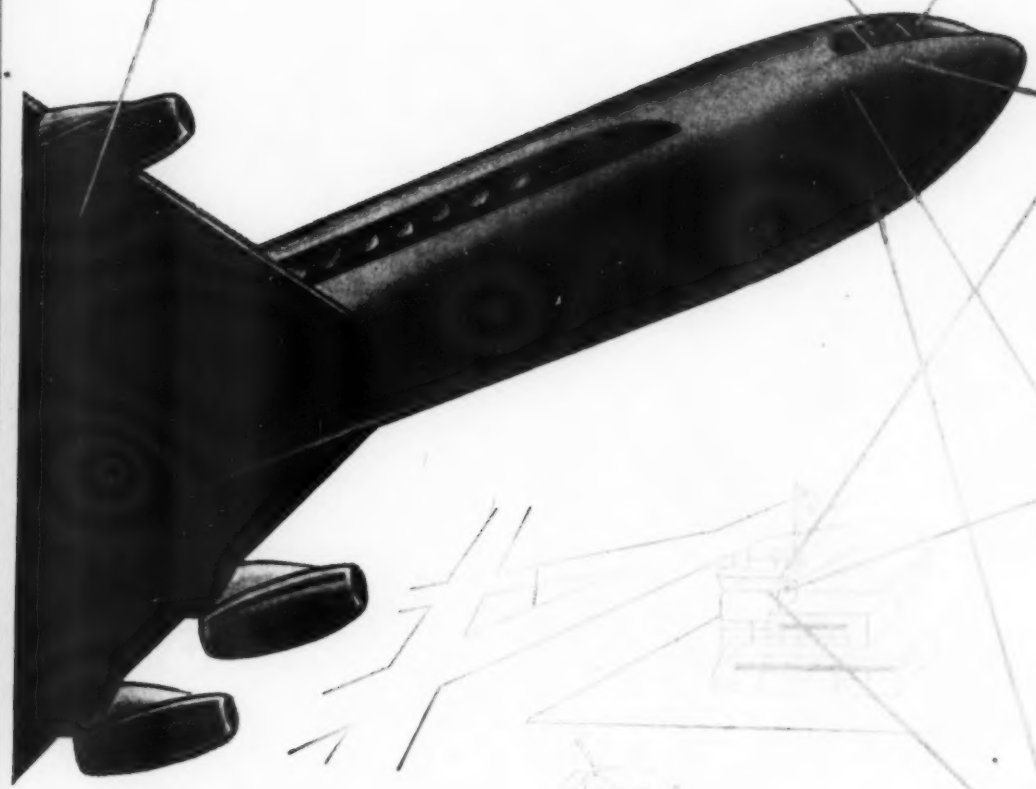

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Ready to take to the air, the complete turbo-prop weighs only 460 lbs. and delivers 960 h.p. from a compact 47.6 length x 23-in. diameter. Using a variety of fuels including automotive and aviation types, gasoline and JP-4, it operates at a low 0.655 lbs. per e.s.h.p. per hr. consumption. Rugged design features and unprecedented ease of maintenance guarantee safe operation and long life.

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speed range, they may be more reliably instrumented and scale effects are held at a more realistic level.

Complete models of missiles and manned aircraft yield good dynamic response data as well as static derivatives. They are used extensively for basic type studies of heat transfer in which no specific configuration is under consideration.

The models are almost always brought to test velocity by reliable solid propellant rockets in as many as four stages.

Procedures vary from firing all rockets on the ascending portion of the vehicles trajectory, to firing some stages on the descending leg to obtain ballistic missile re-entrance velocity in dense air. Once the only source of hypersonic and aerodynamic heating data, they are still a valuable tool even though the more constant test conditions of the hypersonic tunnel are now available.

• **Mass accelerators.** These propel extremely small models down a prepared range where their flight is monitored by sensitive timing apparatus and observed by ultra high speed cameras. Of several possible propulsion methods, the only one in actual use is the light gas gun. Using compressed gas instead of powder as a propellant, these guns have a maximum attainable velocity of approximately 10,000 mph.

Proposed improvements will raise velocity to 16,000 mph. The enormous heat energy of a high-current electric arc discharged in an atmosphere of helium will raise the possible test velocities to about 30,000 mph. Another approach is to use a linear electromagnetic accelerator.

Electric Coil

The final method under active consideration is use of the tremendous bursting energy of an electric coil when a high current is suddenly applied. Principal drawback of this type of testing is its limit of model size to ¾ in. diameter. Correlation with other types of data will be difficult. However, an attractive feature is that the cost per data point will be as small as the models, relative to other testing methods.

Wind tunnel versatility has also been increased using mass accelerators.

Powder charge guns are used to fire models upstream through the test section of wind tunnels to greatly increase their range of testing velocities.

Expansion of superaerodynamic knowledge is certain to lag years behind hypersonic information. There is only one tunnel in the United States (University of California at Berkeley) capable of creating a high velocity stream of separated air molecules. Consequently ballistic missile engineers who must accurately predict trajectories which reach altitudes of several hundred miles face a situation similar to one several years back when slotted throat, transonic wind tunnels were not available. Aerodynamicists then had to complete aircraft designs without reliable information concerning that speed range.

No Comparisons

Even when using the California tunnel, missile men have no strong theory or other test data with which to compare their results. Therefore, there is no easy way to decide on the proper method for reducing their test information to usable coefficient form.

All three U.S. services are financing development projects of various types of vertical lift machines. This is deemed necessary to provide combat forces with the rapid tactical transport and air support required in atomic warfare where prepared airfields will be primary targets.

These diversified projects may be classified in three groups: helicopters and semi-helicopters which utilize rotors and have limited cruise speeds; tail-sitters which obtain their lift from conventional propellers or turbojet thrust and have high-speed potential, and finally multiflapped and tilting-wing aircraft which land with their fuselages in a horizontal position and may also function as conventional aircraft.

Some development engineers believe STOL should be bypassed and full

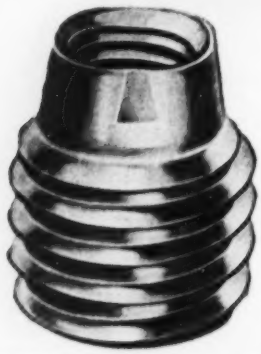
U.S. Research Aircraft—"X" Series

Designation	Manufacturer	Powerplant designation and rating	Overall span, ft.	Overall length, ft.	Overall height, ft.	Remarks
X-1	Bell	1 RMI-6000-C-4 @ 6,000 lb. t.	28 0	34 6	10 8	First to exceed Mach 1, 10/14/47; reached M = 1.04.
X-1A	Bell	1 RMI XLR-11-RM-5 @ 6,000 lb. t.	28 0	35 6	10 9	Exceeded 1,650 mph. (M = 2.5) and 90,000 ft. altitude during tests.
X-1B	Bell	1 RMI XLR-11 @ 6,000 lb. t.	28 0	39 6	10 9	Used for heating studies; pumped propellants.
X-1D	Bell	1 RMI XLR-11 @ 6,000 lb. t.	28 0			Destroyed during test, 8/23/51.
X-1E	Bell	1 RMI XLR-11 @ 6,000 lb. t.	28 0			Has 4% wings, pumped propellants.
X-2	Bell	1 C-W XLR-25 @ 15,000 lb. t.				Exceeded 2,100 mph. (M = 3 plus) and 126,000 ft. altitude during tests; crashed 9/27/56.
X-3	Douglas	2 West. J34-WE-17 @ 4,500 lb.t.	22 8	66 8		Underpowered; now out of service.
X-4	Northrop	2 West. J30 @ 1,600 lb.t.	26 9	23 3	14 9	Semi-tailless sweptwing aircraft for transonic tests. Out of service.
X-5	Bell	1 All. J35-A-17 @ 4,900 lb.t.	32 8	33 5	12 2	Variable-sweep wings; span 23.3 ft. fully swept. Crashed 10/13/53.
X-6						
X-7	Lockheed	1 Marquardt "Bomarc" ramjet				Test vehicle for Bomarc propulsion units. Controllable, recoverable by parachute, unmanned.
X-8						
X-9						
X-10	NAA	2 West. J40 tj.				Guidance and aerodynamic test vehicle for NAA SM-64 Navaho; unmanned. Flights completed.
X-11						
X-12						
X-13	Ryan	1 R-R Avon tj. @ 10,000 lb.t.				Vertical takeoff research. Delta-wing aircraft; in flight test.
X-14	Bell	2 AS Viper tj.				Vertical takeoff research.
X-15	NAA	1 RMI lpr.				Extreme-altitude research; designed for performance above 800,000 ft. Manned aircraft.
X-16						
X-17	Lockheed	3 spr.				Three-stage hypersonic rocket vehicle for ICBM re-entry studies; unmanned.
X-18	Hiller	4 tp.				Tilt wing VTOL.

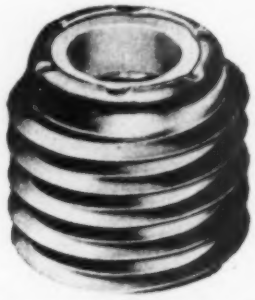
Abbreviations:

All.—Allison
A S—Armstrong Siddeley Motors
C-W—Curtiss-Wright Corp.
lpr—Liquid-propellant rocket
tj—Turbojet
tp.—Turboprop
lb.t.—Pounds of thrust
RMI—Reaction Motors Inc.
R-R—Rolls-Royce, Ltd.
spr.—Solid-propellant rocket
West.—Westinghouse Electric Corp.

FASTENER PROBLEM



Type LH2424, for temperatures to 550° F.



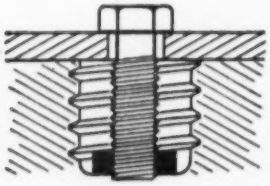
Type N2424, for temperatures to 250° F.

Strong, self-locking threads for tapped holes in soft metals

Tapped holes in soft metals have long presented problems to aircraft manufacturers. Threads wear rapidly, are easily damaged and are susceptible to stripping. Bushings made of harder alloys are a partial solution. Such inserts, however, have a tendency to shake loose under vibration, or to back out when the bolt is removed. The only alternative is to position them with a secondary fastening device such as a key or a "Dutchman" pin which then presents a difficult and costly service problem. In cooperation with aircraft and aircraft engine builders, ESNA has developed a new bushing design which eliminates these problems. Type 2424 bushings are self-locking externally and internally. They provide a one-piece, vibration-proof steel threaded insert that develops AN tensile loads, is dependably self-retaining, yet can be readily removed with simple tools.

Easily inserted in an NC-2 tapped hole, using simple tools, the type 2424 bushings are locked in place by the interference action of the patented Lok-Thred system, which reforms the socket thread to the equivalent of a perfect selective fit.

The internally-threaded sections use one of two thoroughly-proven ESNA self-locking devices. For temperatures up to 250° F., the new bushing is available with the famous red nylon locking collar. For service between 250° and 550° F., it comes equipped with the all-metal LH locking device that has been tested on many types of ESNA high temperature locknuts. Both bushings are available in sizes #10 through ½" and the locking devices provide performance and reusability per Specification AN-N-5b and AN-N-10a.



"Lok-Thred" contour displaces metal from crests of socket threads to produce equivalent of a perfect selective fit. Original socket threads can be reworked as many as ten times and new bushings inserted.

Type 2424 bushings can be installed in any material whose hardness is less than 25 Rockwell C, including aluminum, magnesium, plastic and mild steel castings. Simplified installation and field maintenance techniques save costs. And because Lok-Thred method of external locking creates less hoop stress in the base of the casting, edge distance or boss size is reduced . . . with resulting weight savings.

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effort concentrated on VTOL which is the ultimate goal. However, the Army wants a VTOL craft that will be capable of STOL in a 100% VTOL overload condition. This stems from its belief that adequate power to insure high capacity VTOL aircraft will not be available for some years.

Adequate Power

Heart of any VTOL or STOL development is adequate power. Thus, a large percentage of the funds allocated is being spent developing high power, low weight per hp. turboprop engines. Contracts have been let abroad as well as in the U.S.

New Lycoming and General Electric light turboprops of 1,000-2,000 eshp. have provided sufficient power for current experimental types.

Boundary layer control, necessary for STOL operation, has reached the flight test stage with many U.S. aircraft manufacturers. Some operational planes are equipped with it, although they are still having problems. Main trouble centers are the high-pressure nozzles in blowing systems and the porous skins of suction types. There still has been no general agreement as to the best type of BLC. Blowing requires more power, but increases lift coefficient more than suction. Blowing at the leading edge slat has recently been found to improve maximum lift coefficient by more than .5.

This indicates that high lift coefficients may be maintained at very large angles of attack, resulting in a virtually unstallable wing.

Noise Solutions Sought

Use of large jet engines and the gravitation of people toward military and civil airports is bringing increasingly violent complaints against noise.

Boeing's 707 equipped with derated J57 engines, for example, will have a noise level at take-off power of 130 decibels at 900 ft., a 20 decibel increase over the DC-7.

Reduction of 707 noise to the DC-7 level can be accomplished by creating a more gradual velocity gradient between the high energy air of the jet exhaust and the nearly static surrounding air.

A thrust loss of 2-3% will result using present designs for accomplishing noise reduction. While the airlines are willing to accept this penalty in deference to customer and community relations, the Air Force is not. USAF naturally opposes anything which will restrict maximum takeoff weights.

Noise also can damage structure. Jet exhaust located near fuselage or over the wing has led to failure. Suppressors are being designed to reduce sound energy in the critical lower frequencies—150 to 1,200 cps.

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W. E. Gleason

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Buying Supervisor

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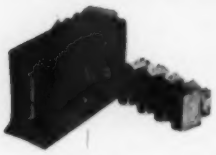

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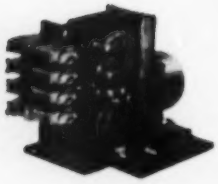

THERMOCOUPLE SAMPLING

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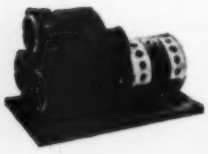

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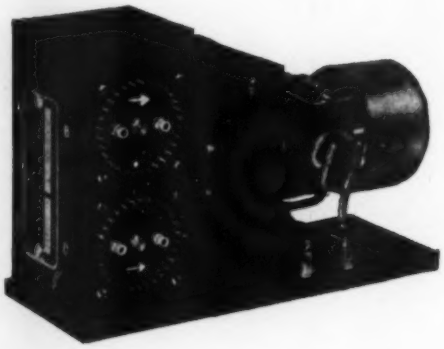

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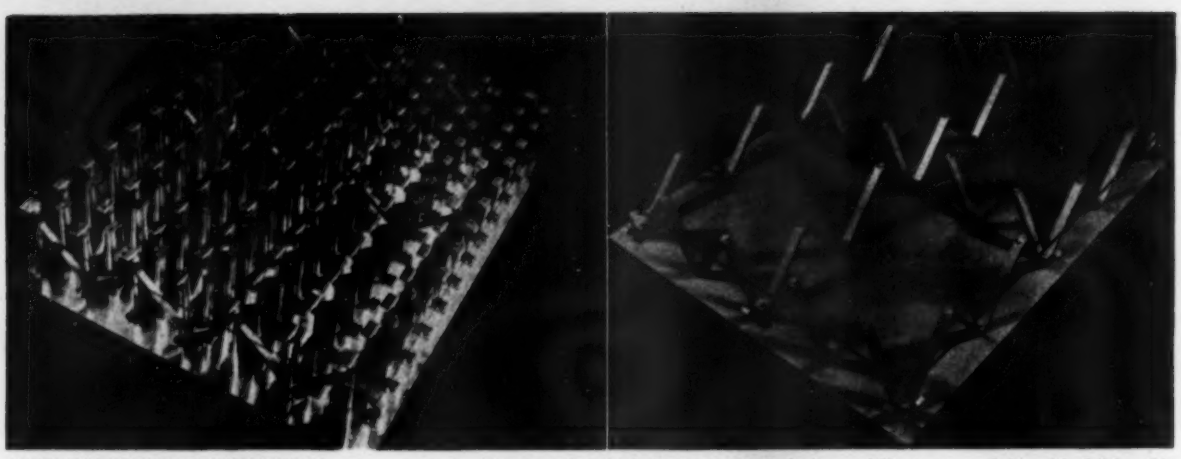


ALTERNATE WING STRUCTURES for supersonic aircraft exposed to high heat rates include Inconel-X structure (left) with 0.1-in. skin supported by corrugated spar webs at close intervals and truss-type ribs; and (right) ¾ to ½-in. magnesium backed by aluminum alloy webs and ribs.

High Speed Structures Keyed to Materials

By Irving Stone

Structures for high speed aircraft and missiles are closely keyed to basic design and the critical variable of materials in relation to high temperatures.

One major question is how extensively titanium alloy is going to fit changing structural requirements. It is vigorously advanced by some airframe builders, not particularly stressed by others.

One of the most active proponents of titanium alloy structures is Boeing Airplane Co. Its designers foresee a distinct role for the material in aircraft where structural temperatures may reach at least 800F. With future development, it may become competitive with steel for even higher temperature applications.

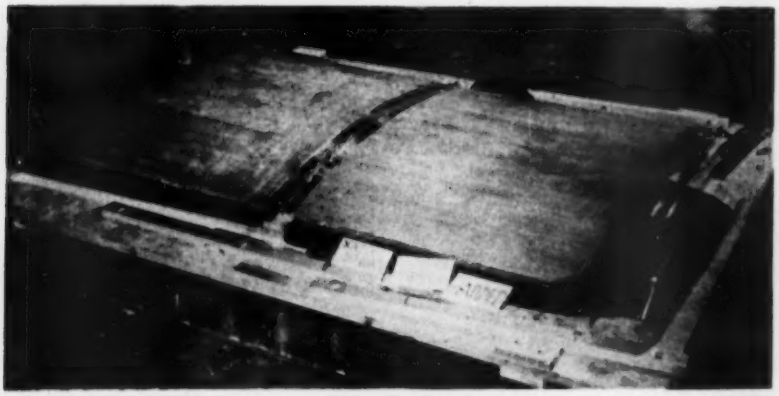
Boeing is considering titanium alloys not only for future large supersonic aircraft designs but for subsonic applications as well. Reason: minimum airframe weight gives maximum range or maximum payload for a given range. For the type of aircraft Boeing is considering—large bombers and transports—these factors are of prime importance.

Use of heat-treated 6Al-4V titanium alloy instead of a typical high-strength type heat-treated steel such as Type 422 will result in a 30% saving in airframe weight, Boeing engineers estimate. This will provide a 15% increase in radius or a payload increase of approximately 30% of the structural weight with no loss in range.

Related to 7178-T6 aluminum alloy, savings in weight and improvement in performance would still result.

These advantages are possible, Boeing engineers say, because of the superior strength/weight ratio of heat-treated 6Al-4V titanium alloy. The material also has good creep characteristics at temperatures up to about 800F, and good notch sensitivity, fatigue resistance and corrosion resistance.

Boeing's projected use of 6Al-4V stems from a wealth of design studies involving about 300,000 combinations of various materials, gages, methods of stabilization, and temperatures, etc., supported by structural tests on panels embodying the more feasible characteristics.



CURVED HONEYCOMB sandwich panel developed by Boeing Manufacturing Research Div. using .032-in. 6Al-4V plus titanium alloy sheet and 17-7PH stainless steel core.

Design Challenge

Most serious challenge to the designer in the use of a material such as heat-treated 6Al-4V is to design structural components which will provide stability for very thin high strength sheet. A large percentage of the external surface of the aircraft will use this stabilized thin-gage construction.

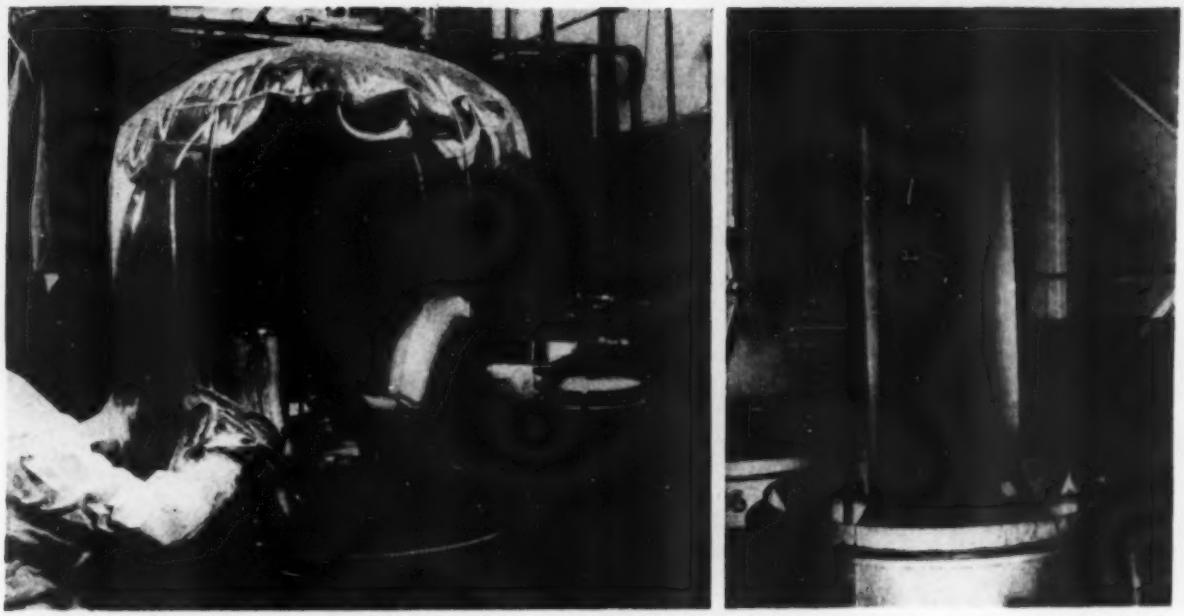
One approach is the use of titanium alloy or steel honeycomb core. Corrugations or waffles spotwelded to the thin surface sheet is another.

Thinner sheet—gages down to .005 in. in 36-in. widths could find application in thin-skin stabilized structures, say Boeing designers.

With the Air Force, Boeing has sponsored development programs with various titanium producers to supply heat-treated mill products, now only available in experimental quantities. As a result, availability of commercial quantities of titanium alloys in the range of 150,000 to 170,000 psi. ultimate tensile strength is expected to be available soon.

Heat-treated 6Al-4V material with which Boeing is now working develops 150,000 psi. minimum tensile strength, a value expected to be boosted to 170,000 psi. with additional heat-treat experience and refinement.

Other developments expected which



TITANIUM ALLOY parts (left) being welded at Boeing in inert-gas-filled plastic chamber; method is used for small configurations. Supporting fixtures (right) used at Boeing for 6A1-4V titanium were especially designed to minimize distortion.

will boost use of titanium alloy are improved gage tolerance to permit production of more uniform quality formed parts and closer weight control, longer and wider sheets to lighten structures by reducing number of joints and improved flatness to provide greater aerodynamic smoothness and facilitate manufacture of sandwich construction.

Vital Factor

Available 6Al-4V sheet meets stainless steel specification limits in accordance with AMS 2242A, but Boeing designers would like to see the material developed to meet aluminum alloy specifications.

Vital factor underlying the general introduction of titanium alloys for aircraft and missile structures is the resolution of manufacturing difficulties. The material will have to be handled routinely by shop processes translating designs into structural hardware. Boeing's Manufacturing Research Section is studying forming, machining, heat treating and welding.

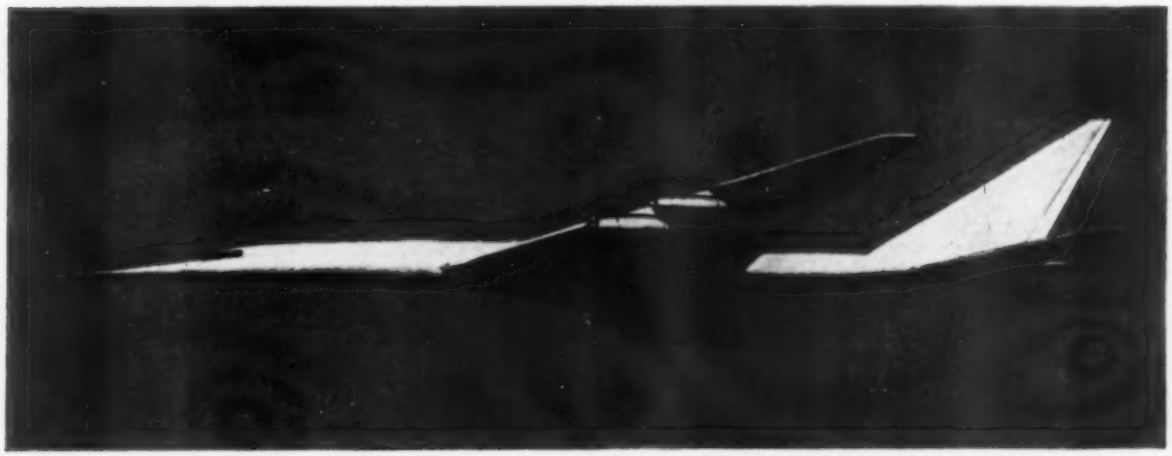
The material cannot be formed to all normal configurations at room temperature. At elevated temperature four basic problems are introduced: one is to raise the material to 1,000-1,500F range temperature, second problem is to raise tooling to temperature and maintain it during forming, third is maintaining aircraft tolerances during high heat forming so that warpage is not excessive upon cooling, and fourth is to protect the metal from absorbing gas contaminants at high temperature.

Hot Forming

Using electrical heat, the part blank, die, or both may be heated. The part may be used as a resistance element. Induction heating also is being studied. Internal electrical heating elements may be used in the die.

Gas heat may be applied to the die by internal burners. Part may be heated over a gas flame. Torch heating does not provide consistently uniform temperature.

Furnace heat has been applied in the



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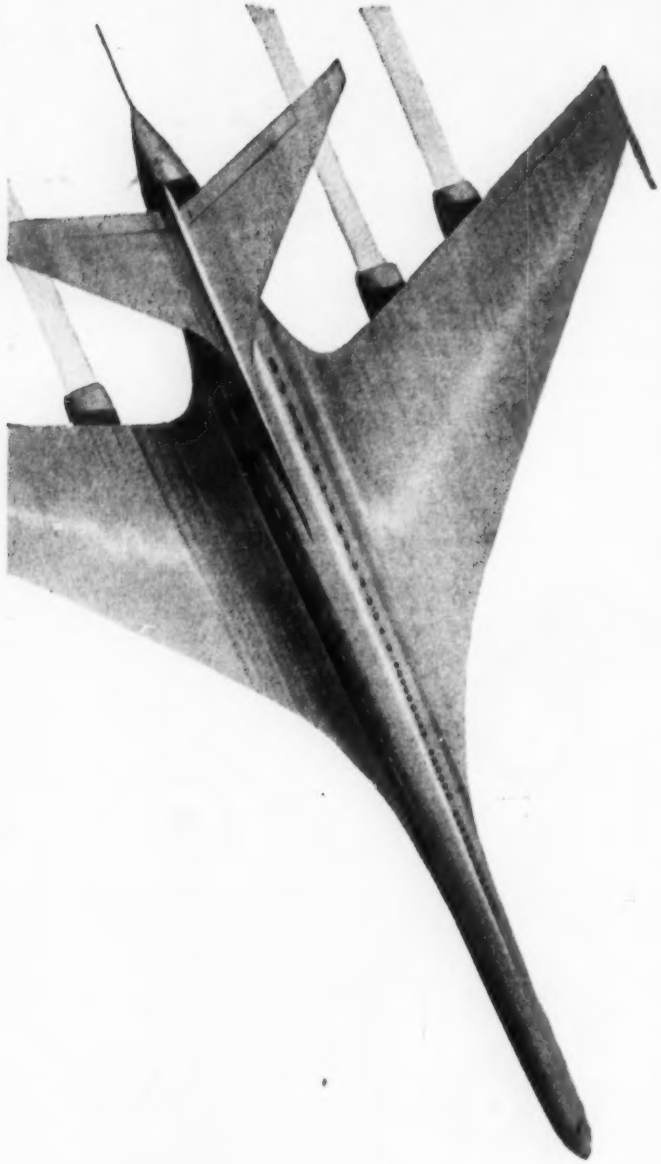

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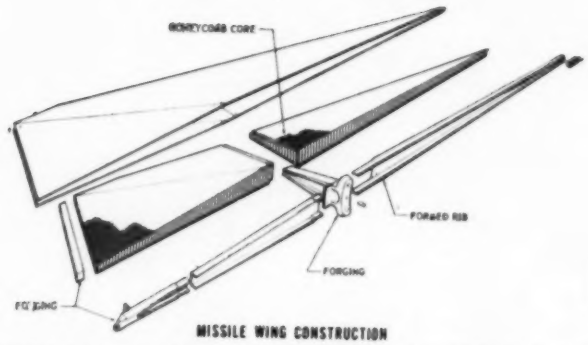
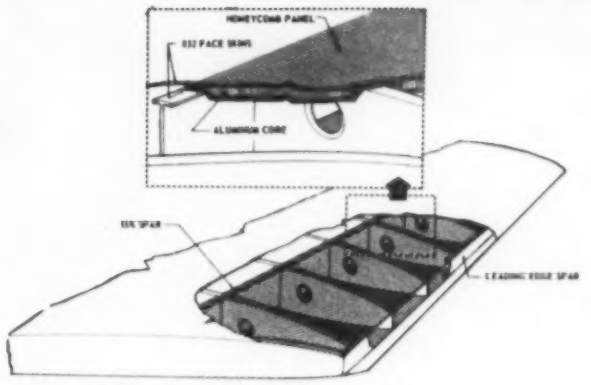


MISSILE WING CONSTRUCTION



HONEYCOMB LEADING EDGE CONSTRUCTION

WING for supersonic missile designed by Northrop (left) embodies adhesive-bonded aluminum honeycomb core, forged and formed ribs. Adhesive-bonded aluminum honeycomb sandwich (right) applied to leading edge of Northrop Mach 2 fighter design.

lower temperature ranges around 1,000F. Disadvantages are heat loss in transfer of part to forming machine and occasional need for reheating during forming cycle. An advantage in contrast with electrical and gas heating is that the part is heated at the area of forming, promoting closer control of temperature, more efficient forming.

Tolerance Control

Control of part tolerances during and after forming depends on die design and use of tools, and holding fixtures in the aging operation of the heat-treat cycle.

Boeing has developed ceramics for successful elimination of galling during forming. In addition to serving as a lubricant, the ceramic prevents scale formation on the surface of the part.

Heat treat is required for optimum physical characteristics of the 6Al-4V titanium alloy. First stage is solution heat treat, in which the material is heated to 1,700F for 30 min., followed by a water quench. This is done to parts which are not formed, as well as those to be formed.

Second stage, the age hardening treatment, is done for four hours at 1,000F. Parts get this treatment after forming. A protective coating of silicone-base aluminum paint prevents gaseous embrittlement and scale formation.

In welding, both fusion and resistance techniques have been developed to the point where manufacturing criteria has been established for economical production of 6Al-4V parts despite relatively closer control required.

For fusion welding, methods used for stainless steel have been refined. Cleaning of the alloy has been more critical; closer control of the inert gas rate of flow, quality and degree of coverage is required. In one approach a plastic bag contains the part and the protective atmosphere.

For resistance welding, standard equipment can be used but closer control of all welding variables is required. Higher and consistent weld shear strength can be obtained by minimizing surface contamination.

In the relatively difficult field of titanium alloy machining, Boeing has applied basic research data, obtained under Air Force contracts with industry, to its specific problems in cutter research relating to titanium alloy smearing tendencies, unusual chip formation and low thermal conductivity of the material. Practical solutions have been developed for cutter geometry and material quality, and control of tool grinding practices.

Machine practices for typical steel and aluminum alloy parts have been evaluated on corresponding 6Al-4V configurations. It was found that machines used for cutting steel were adequate for titanium alloys. Those specifically designed for aluminum alloy, such as spar mills, skin mills, and routers, required modification, generally, in speed, power and rigidity. Indications are that assembly drilling will require more rigid tooling and slower speed power feeds.

In the overall machining field, equipment modification, fixture and tooling requirements, operator techniques, optimum coolants and lubricants, are still being studied to establish procedures.

Dissent on Titanium

Another prominent design group believes that use of improved aluminum alloys will delay extensive use of titanium alloys. New aluminum alloys appear to be applicable to aircraft operating at about Mach 3, these designers say. Example cited is Alcoa's recently introduced X2219-T6, which could be used for skin temperatures up to about 500F. It is likely that the next generation of fighters or supersonic bombers might make extensive use of such a material.

Another reason advanced for retention of aluminum alloy is that operational aircraft will not be flying at sustained Mach 3 speed in the immediate future because powerplants with reasonable fuel consumption will not be available.

Not for Missiles

Some missile men haven't included titanium alloys in their plans.

One prominent organization designing and building missiles has not used titanium primarily because of the relatively high cost of the material, particularly since a missile is pretty much a one-shot article.

In the temperature region where titanium alloy would normally be used, steel has been employed, this company says, even though a small weight penalty has been involved. By the time titanium alloys come down to a competitive price, it adds, the material no longer will meet the temperature requirements for missiles and the use of steel or some other higher temperature material will be mandatory.

In addition to high cost, procurement and fabrication difficulties have discouraged the use of titanium alloys in missiles, claim engineers of another top missile activity. "If it were the only material that had the required properties, we would bend over backwards to use it," they declare. Instead of using titanium alloy for its structural efficiency at temperatures in the 600-900F range (structural temperature as distinguished from boundary layer temperature), they say Types 321, 347 and 400 stainless steels and 4130 steel are being used.

An alternate approach is to use magnesium or aluminum alloys in gages thick enough to act as a heat sink, so that the temperature of the load-carrying material does not reach the temperature of the boundary layer. Thickness required for these materials should not introduce additional weight in comparison with the heavier, higher-tem-

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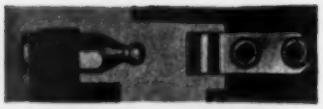

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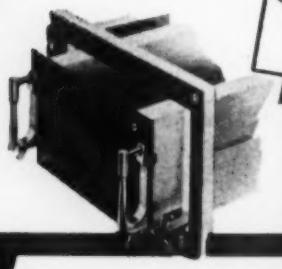

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perature materials for which they are substituted.

In one comparative study for a high-speed high-temperature test vehicle, a ⅜- to ½-in. magnesium skin backed by aluminum alloy truss-type spars and ribs, was about 20% lighter than an Inconel-X structure using 0.1-in. skin supported by corrugated spar webs, closely spaced, and truss-type ribs. The magnesium-aluminum structure also would simplify design and manufacturing.

Generally, in the 900-1,200F temperature range, primary structural material of the stainless steel types, nickel-base alloys and cobalt-base alloys, etc., appear attractive, missile designers claim. These materials appear applicable for the immediate future, since reports are that for the period 1957-1960 most airborne missiles are not being designed structurally to withstand steady-state temperatures at speeds as high as Mach 4 to 5 (1,100 to 1,800F), but for a relatively short structural life, at temperatures which can approach 1,000F.

In the picture are thrust-borne (ballistic) missiles which can develop structural temperatures capable of softening or melting the common structural materials. One approach to this problem is the heat sink, with material of adequate type and thickness. Designers also are considering using ceramics, cermets and composite makeup on the outer surface of the structure. Big hurdle with ceramics and cermets, it is claimed, are their relative brittleness and fabrication and attachment problems. With a composite structure, such as one using a metal inner face and a ceramic outer face, there are bonding difficulties, problems associated with coefficients of expansion, attachment difficulties

Honeycomb Structure

Insulating type mineral fiber materials also are being considered. In the higher structural temperature ranges, designers contemplate endothermic (heat absorbing) vaporization of an outer protective material for keeping down the temperature of the primary structure underneath. In effect, this form of erosion means that the structure becomes lighter during flight.

Honeycomb structures have a place in missile makeup. They already have been adapted for high speed aircraft construction (AW Oct. 8, 1956, p. 29; June 27, 1955, p. 36). For service where bond temperatures are above 1,000F, brazed all-metal honeycomb sandwich appears promising, designers say, and already has been used to a limited extent in missile structures. Resistance-welded honeycomb sandwich, now in the experimental stage, may prove more attractive because of greater strength/weight efficiency and higher temperature potential.

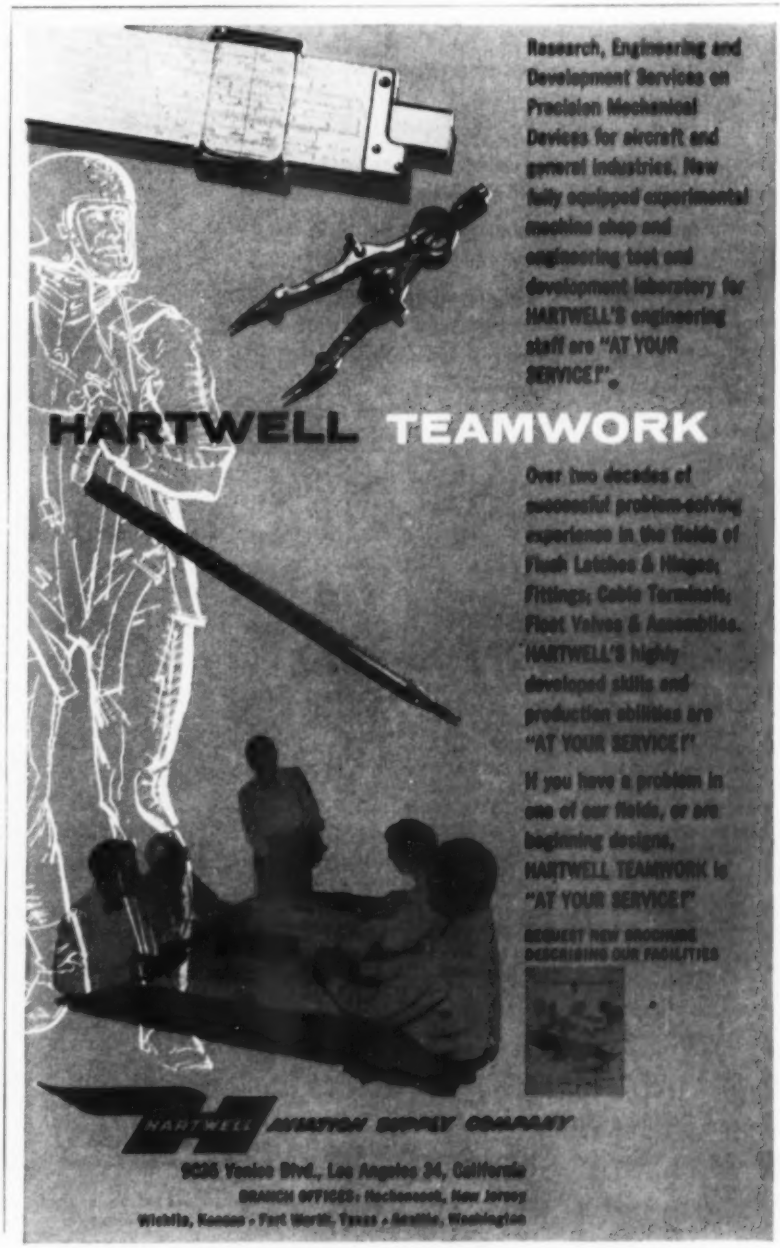
For adhesive-bonded honeycomb sandwich, the structural temperature in the bond must not exceed that at which the bonding material shows creep or excessive deflection. Up to 400-500F, epoxy bonding resins are used. In the 500-1,000F range, silicone and other type bonding resins are being adapted.

Example of an adhesive-bonded aluminum honeycomb sandwich structure is the wing of a supersonic missile designed by Northrop Aircraft, where structural temperature has reached approximately 400F for a short period.

Honeycomb structure has been static tested at the new elevated temperature facility at Wright Air Development Center, and flight tested in the supersonic regime. Both tests demonstrated the structural integrity of the honeycomb makeup for the temperature range encountered.

Controlling factors which dictated the use of this type of structure included aeroelastic problems (wing flutter, skin panel flutter, wing reversal); minimum structural frequencies required for autopilot operation; stringent airfoil smoothness; thinness of airfoil, limiting use of conventional structural shapes and fasteners; and economy.

Comparison with a conventional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structure showed that only 39 parts were required for the honeycomb sandwich structure as against approximately 650. The honeycomb structure used only 26 fasteners and 2 formed metal parts compared to 620 and 15, respectively, for the conventional arrangement.

The honeycomb wing has a single piece aluminum alloy skin, chemically milled to minimum gage meeting strength and stiffness requirements. A full-depth honeycomb core of varying densities is bonded to the skin with high temperature Epon 422 adhesive.

Main spar and parts of the inboard rib are forged. Other parts of the inboard rib are bent up from sheet stock. These components, as well as the honeycomb core, are adhesive-bonded to the skin under low pressure.

Construction of the missile body follows a conventional pattern involving the use of aluminum alloy, steel, and reinforced plastic sections.

Mach 2 Aircraft

Northrop also uses adhesive-bonded aluminum honeycomb sandwich in aircraft design projected for Mach 2 speeds. In this application, full-depth aluminum honeycomb is used in the stabilizer, which incorporates an extruded main spar to carry bending loads, and a formed false spar at about 75% chord, which serves as the aft shear-carrying member for the main torsion box. Skin is chemically milled to taper spanwise from 0.10 in. at the root to .040 in. at the tip, and incorporates a riveting land along the spar area.

Vertical fin leading edge incorporates Fiberglas skin and core combination to permit transmission of radio signals to the antenna housed behind it.

Rudder uses full-depth honeycomb aluminum sandwich from leading to trailing edge with primary bending loads carried by leading edge spar.

Ailerons and flaps embody full-depth aluminum honeycomb for about 10 in. of the trailing edge section to minimize fabrication problems and resist effects of acrodynamically induced vibration and buffet.

Wing tip also uses honeycomb makeup and extends about 25 in. inboard.

Wing leading edge ahead of the main bending box uses aluminum honeycomb panels to provide aerodynamic smoothness between leading edge ribs. This results in a saving in the number of ribs and allows the leading edge to remain unbuckled up to limit loads. Actual construction embodies a sheet metal, unstiffened nose section, leading edge nose spar followed by upper and lower honeycomb sandwich panels riveted to the nose spar and, at their aft ends, to the 15% main bending box spar.

Offering big potential in the future are phenolic- and silicone-resin-impregnated reinforced plastics now in the experimental stage. These are projected to withstand temperatures in the range of 2,000 to 10,000F, retaining structural integrity for periods of time in seconds for the high end of this range and up to about two minutes at the lower end of the range. Erosion would occur but the part would be designed so that there would be enough material remaining to insure structural strength. Low conductivity of the material would permit use of a reasonable thickness, plastic designers claim.

Reinforced Plastics

Meanwhile, reinforced plastics have found substantial routine application in missile structures, primarily in wings and fins. Reasons for use include favorable strength/weight characteristics at temperature, ease of fabrication, smooth aerodynamic finish and reasonable cost.

Reinforced plastic laminates impregnated with epoxy resin are suitable for structural applications up to 400F. Laminates impregnated with phenolics and modified polyester resins are reported good for structural applications in the 400 to 600F range, with the phenolics used for the high end of the

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range. Silicone-resin-impregnated reinforced plastics will take temperatures as high as 1,250F, it is reported. These temperatures refer to continuous exposure times of ½ to 1 hr. before deterioration of strength characteristics.

Missile wings have been fabricated in spans as large as 15 ft., although this size is considered unusual. Most spans range to about 5 ft.

Construction might involve a Fiberglas skin with full-depth Fiberglas honeycomb core, perhaps with Fiberglas spar inserts if load requirements dictate use of these members. Another structural form might use Fiberglas skin with spars and ribs of the same material. Fiberglas honeycomb sandwich panels used as skin might be supported by a multispar arrangement.

Other construction could use Fiberglas skins enclosing high-temperature foamed core. Asbestos reinforcement may be used in some instances instead of Fiberglas for high heat applications.

Metal normally is not used except for attaching members.

Wing thickness may run from approximately 1 to 9 in., depending on aerodynamic requirements. Smaller thicknesses probably would use foamed core between skins, or molded solid Fiberglas laminate.

Missile fins of plastic makeup generally use, in the thinner configurations, foamed core between skins or full-depth honeycomb sandwich.

An interesting example of reinforced plastic use is in the hypersonic test vehicle (HTV) developed by Aerophysics Development Corp. (AW Jan. 7, p. 48). The nose cone incorporates a Fiberglas plastic inner shell and nickel outer shell with a layer of Refrasil between for insulation.

More study and better coordination of structural test data for a broad range of materials are needed, airframe designers claim. In aircraft applications for those vehicles operating in the region of Mach 3, there will be a need for extensive study to determine the effects of repeated exposure to temperature and load to ascertain suitability to resist permanent deformation or physical changes which will reduce mechanical properties.

Some companies are conducting this form of research, but there is a great need for interchange of information, designers feel. Also of prime importance is the need for standardization of test procedures to insure reliable comparison of material properties.

One complaint voiced by missile designers is that there is a lack of test data for common airframe structural materials at elevated temperatures for very short exposure times (10 sec. to 15 min.). Most data available to them, they say, are based on exposure time of 30 min. or more.

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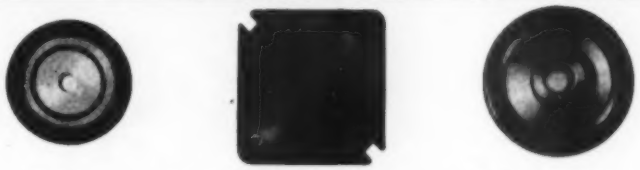

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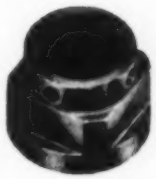

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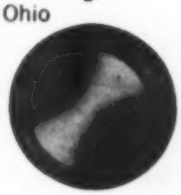

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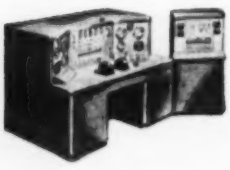
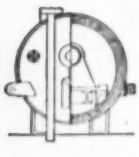
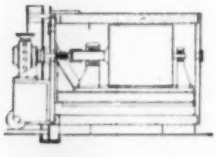






Propulsion Bucks Heat, Fuel Limits

By Robert Cushman

New York—Higher temperature materials to permit higher cycle temperatures and new high energy fuels that do not absorb the entire weight and volume allowance of an aircraft or missile are keys to future propulsion progress.

How designers made advances while the search for these better materials and fuels went on was a measure of propulsion progress last year.

Last year saw some long hoped-for propulsion needs filled:

• **Supersonic high altitude turbojets.** The Pratt & Whitney J57 proved that, given supersonic airframes, it could propel them to Mach 2. The General Electric J79 turbojet is giving the F-104 Mach 2 capability and is expected to give the B-58 Mach 2.3 capability in level flight. It has powered the Grumman F11F-1F to 72,000 ft.

• **High performance rocket motors.** The Curtiss-Wright throttlable liquid propellant rocket motor which boosted the Bell X-2 to its 2,200 mph. speed and 126,000 ft. altitude records and the General Electric liquid rocket motor for the first stage of the Vanguard rocket which will thrust the Earth Satellite Vehicle into its 300 mi. high, 18,000 mph. orbit are evidence of the gains in the rocket propulsion field.

• **Better developmental facilities.** NACA's Lewis Laboratory in Cleveland opened its 10 ft. x 10 ft. test section supersonic propulsion wind tunnel in time to run full scale tests of a complete propulsion pod for the B-58. The 16 ft. x 16 ft. test section transonic propulsion wind tunnel at USAF's Arnold Engineering Development Center, Tullahoma, Tenn., was operated for the first time. Navy's Trenton, N. J., propulsion test facilities were able to verify that the Westinghouse XJ54 turbojet could maintain combustion at a simulated 80,000 ft. altitude. The down-range missile flight test facility extending from the Cape Canaveral launching sight, Patrick AFB, Fla., has been sufficiently completed to evaluate first ICBM (intercontinental ballistic missile) and satellite launching vehicles. Since many of the new propulsive systems have to supply lift and control forces as well as propulsive forces, flight testing now means as much to the propulsion contractors as it does to the airframe manufacturers.

• **VTOL/STOL engines.** General Electric and Lycoming have each completed 50 hr. flight qualification tests with their T58 and T53 turboshaft engines. VTOL/STOL competition participants now have the promise of powerplants to build prototypes around.

Last year also had its propulsion disappointments:

• **No major breakthrough** in high temperature materials. The thermal limit, as far as turbine inlet temperatures go, is still under 2,000F barrier instead of the 2,500F needed for every phase of gas turbine development except subsonic chemically-fueled turbojets.

• **Nuclear powered airplane** is farther away than had been thought, Defense Department admitted. Big technical problem was given as shielding weight.

• **Top limit of 373 seconds** specific impulse was firmly set upon the performance expected from the best combinations of stable chemical fuels for rockets. Taming the free-radical chemical fuels which could give many times this value is yet to be accomplished.

Supersonic Turbojet

In many ways the performance of the GE J79 in the Lockheed F-104 was the highlight of the past year. After years of conjecture as to the possibility of a thoroughly supersonic propulsion system for ground based manned fighters, the appearance of a fully integrated inlet, gas-generator and nozzle which would permit "effortless" supersonic flight was an encouraging sign.

The J57 can also provide supersonic capability and with good subsonic cruise fuel consumption. But the J79, because of its extreme lightness for its size, can put a military craft at altitudes above the enemy.

In the case of the B-58, which has one of the most advanced propulsion systems designed, propulsion credit must also go to Minneapolis-Honeywell, which helped Convair engineer the variable inlet geometry.

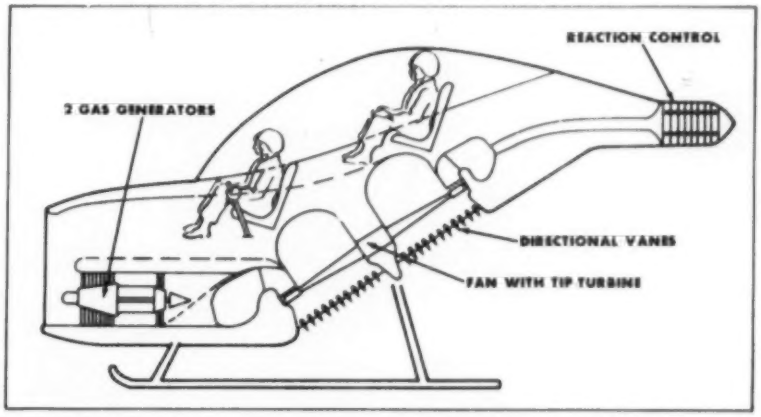
GE's most notable single contribution in the J79 is its lightweight, high-flow compressor. Considering the wide variation in conditions in which a supersonic turbojet compressor must operate, the magnitude of the engineering job becomes apparent. The compressor must be able to idle smoothly on the ground. It must have good acceleration and handling characteristics for take-off and landing. It must have good compression ratio for fuel economy for subsonic cruises. During acceleration to Mach 2 it must be able to accept the higher pressures and temperatures from the supersonic ram inlet ahead of it and emit the proper flow and pressure level for the combustion system, turbine afterburner and supersonic converging-diverging nozzle downstream, despite the back pressure from the extra fuel pumped in for acceleration.

Apparently the 17-stage single spool compressor which has variable incidence on the first seven stator blade rows answers the requirements.

Commercial Use

That GE expects to use the same variable stator design for the subsonic CJ805 commercial J79 version where low specific fuel consumption is paramount and is using the principle on the T58 turboshaft which must have both a high compression ratio for its scaled down size and unusual freedom from surge for VTOL/STOL operations indicates basic design flexibility.

The J79, J57 and J75 are not the



GE SUGGESTS that T58 gas generators ought to be used to direct-drive a large ducted fan in this VTOL's belly. Tip turbines on fan convert high-speed, hot jet from T58s into large low-speed, cold jet for efficient take-off propulsion.

only true supersonic engines. Westinghouse claims that its personally financed J54 has supersonic capabilities. Westinghouse engineers say that by using mid-compressor bleed and variable compressor entrance guide vanes they have been able to keep to a simple single spool which is light enough for its thrust and frontal area to permit supersonic flight.

Westinghouse points out that higher compression ratios are not needed when the turbine blades cannot be overtemperatured. A good percentage of the compression is obtained from the flight speed, it notes.

Fuel Penalty

However, too simple a compressor design will not produce the high compression ratios needed for best subsonic fuel economy. Some of its defenders argue that this is unimportant in high altitude interceptors.

Current resurgence of the single spool engine does not mean the end of split compressors for supersonic aircraft. Although the J57 and J75 are probably too heavy for frontal area and thrust to power an airplane beyond Mach 2, F. H. Keast, Deputy Chief Engineer, Orenda Engines Ltd., Malton, Ontario, believes that the multi-spool compressor engine is still best for supersonic flight. The important thing is that engine designers now appear to have the compressor design problems well in hand.

Large Supersonic

Large supersonic ramjets have apparently jumped out of wind tunnels into 48 in. diameter powerplants. Photographs of the lightweight hardware which Curtiss-Wright is using for its Navaho ramjet nozzles (AW Nov. 26, p. 69) and other photographs of the burner sections of the Navaho ramjets indicate that last year was a year of progress for ramjets. Because they half-solve the temperature problem by being able to ignore turbine inlet limitations, ramjets are certain to become increasingly important in the weapons race.

VTOL/STOL Powerplants

Lycoming's T53, its soon-due T55, and GE's T58 are mentioned in plans for all new U. S. VTOL/STOL flying test beds. Across the ocean Rolls-Royce has apparently been successful in working longer life features into its RB.108 version of the expendable Soar turbojet, five of which will be used to direct-lift the Short Brothers S.C.1 research craft off the ground.

An indication of the extent to which engine manufacturers are participating in the design of VTOL/STOL craft is given in the sketch by Peter Kappus of GE, who told a meeting of the IAS that only by full integration between powerplant and airframe manufacturers can the timely realization of VTOL/STOL virtues be accomplished. Kappus' suggested that the high energy jet from the powerplant be used to spin a large diameter rotor so that the resulting larger area mass of slower moving air would have higher VTOL propulsive efficiency.

Temperature remains the most stubborn barrier to propulsion progress. Though higher turbine inlet temperatures are not needed for the high subsonic jet airliners, they are for supersonic turbojets. These must go on from the 1,000F compression temperatures left by the compressor rise and add another 1,000F or more to drive the turbine and leave a high enough exhaust temperature for the high exit velocities needed to achieve supersonic flight.

High turbine inlet temperatures are also needed for VTOL/STOL power generators which likewise need a combination of high compression ratio and turbine inlet temperature to achieve the 10:1 plus power to weight ratios which manufacturer's engineers are currently predicting.

Inlet Temperature

Where a subsonic turbojet can get away with 1,600F inlet temperatures, a Mach 2.5 aircraft ought to have 2,000-3,000F inlet temperatures.

Turboprops cruising at 460 mph. in the stratosphere would gain 50% in specific power (hp. per engine weight) combined with a 10% reduction in fuel consumption if they could maintain 2,000F inlet temperatures instead of 1,500F. This, in effect, would mean that certain aircraft which today must operate from a runway might be redesigned for STOL, or even VTOL, and cruise more efficiently in the bargain.

The most promising higher temperature turbine blade material is ceramic-coated molybdenum alloy. This might be good for 2,500F. However it has not yet been reduced to practice. If the delay in perfecting high temperature turbine blade materials continues, further attempts will be made to cool blades artificially.

Engineers of Britain's National Gas Turbine Establishment have calculated that at 2,200F inlet temperature, 80% of the thrust achieved at Mach 2.0 directly by having high temperature blade materials could be achieved by diverting 1½% of the engine airflow through hollow turbine blades.

Their figures indicated that, compared to a low temperature engine which must use afterburning to produce the same thrust, a 20% gain in specific fuel consumption could be obtained.

Only the subsonic turbojets slated for the commercial transports are not

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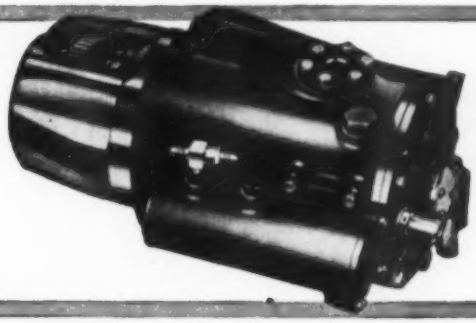

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DOUGLAS K. BAILEY received his BS degree from the University of California. He joined North American ten years ago as a senior design engineer. Today he is chief, Missile Design Section—responsible for missile design engineering and analysis. Doug and his family live in Long Beach where he participates in golf, bowling and sports car activities. He is currently organizing road races in Southern California for the Long Beach MG Club.

Unprecedented programs have been completed and more are to come. Others are being developed, modified and perfected as we enter another exciting phase following a successful flight test program at Patrick Air Force Base using a test vehicle known as the X-10.

The fascinating nature of this work has already attracted the world's best informed missile men. Top-tier men have opportunities in almost every field of engineering—including some of the most advanced work being done today in aerodynamics, thermodynamics, high temperature materials and aero-elasticity.

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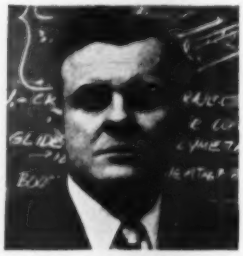

Navy vet **GEORGE W. JEFFS** earned both his BSAE and MSAE from the University of Washington. About 9 years ago he started his professional career with North American as a junior aerodynamics engineer. Now, 5 promotions later, this 30-year old veteran of missile work is chief, Advanced Design Section. He lives in Downey, California with his wife and 3 children. His hobbies include fresh-water fishing and hunting for quail and pheasant.

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plagued by stiff temperature demands. With present subsonic engines, increased turbine temperature would only raise the jet velocity farther beyond the aircraft velocity and thus lower the propulsive efficiency.

To achieve maximum fuel economy, Rolls-Royce believes that its Conway bypass turbojet is the answer. Foreign airlines ordering U. S. jets last year specified this engine frequently.

In this engine the temperature trend is reversed. To produce what is claimed is the lowest fuel consumption engine in existence, Rolls-Royce has split the airflow through the engine. Two thirds of the flow is sent through the normal combustor-turbine path and the remainder is bypassed outside in its own ducting until it rejoins the main flow at the nozzle.

By employing 2% of the airflow to cool the turbine blades artificially, Rolls-Royce is able to run the turbines at an efficient 1,900F.

Rocket Motors

Present rocket propulsion systems, liquid and solid, are only able to sidestep their temperature problems by their very short durations. Extending the X405 Project Vanguard rocket design duration to the needed 150 seconds from the 103 seconds of Viking II was a major development goal. Only by careful redesign of the chamber and nozzle cooling system has GE been able to stretch burning time without melting out the nozzle in 6,000F combustion temperatures.

The expected trend away from regenerative cooling of the rocket thrust chamber will not help the situation. Search for high energy rocket fuels near 373 second specific impulse will result in fuels and oxidizers whose bonds are so weak and vapor pressures so high that it will be dangerous or otherwise impractical to use them for regenerative cooling.

After a high temperature materials breakthrough, the most pressing need is for a fuel breakthrough.

A promising source of propulsive energy are free radicals, as atomic hydrogen. By refrigerating atomic hydrogen to temperatures near absolute zero it can be kept liquid and relatively inert and can be passed to the motor via nose cone and airfoil leading edges to cool those parts while being pre-heated. Impulses of 600-4,000 seconds have been claimed for these fuels, but no practical means of handling them has been devised.

Atomic fuel, being used in Navy submarines, appears to be a ready answer, but a vast engineering job remains to be done before a nuclear system can be made produce the thrust over weight levels needed for aircraft.

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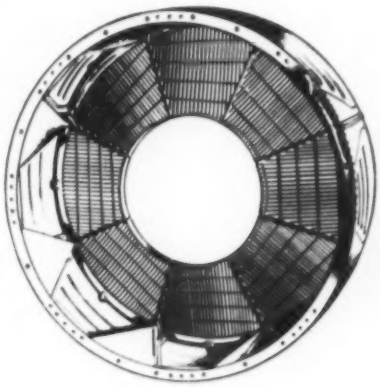

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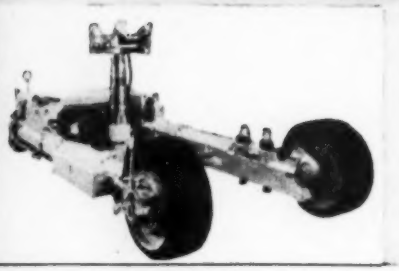
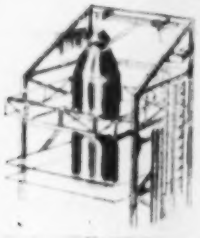
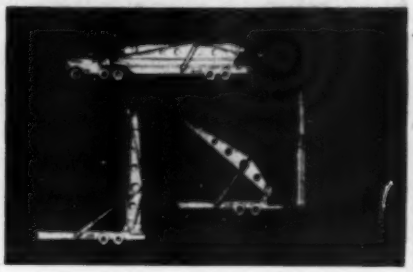


Mobile heavy-devices lift built by Cleveland Pneumatic to raise a heavy weapon 150" from ground and position it within $\frac{1}{32}$".



Servicing segment of missile work stand and tower as conceived by the project engineer of the Special Products Division.



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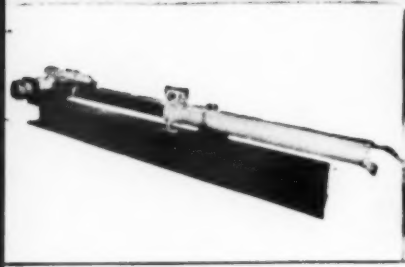
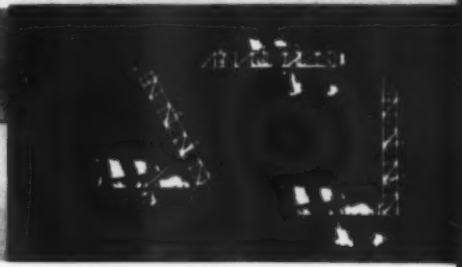


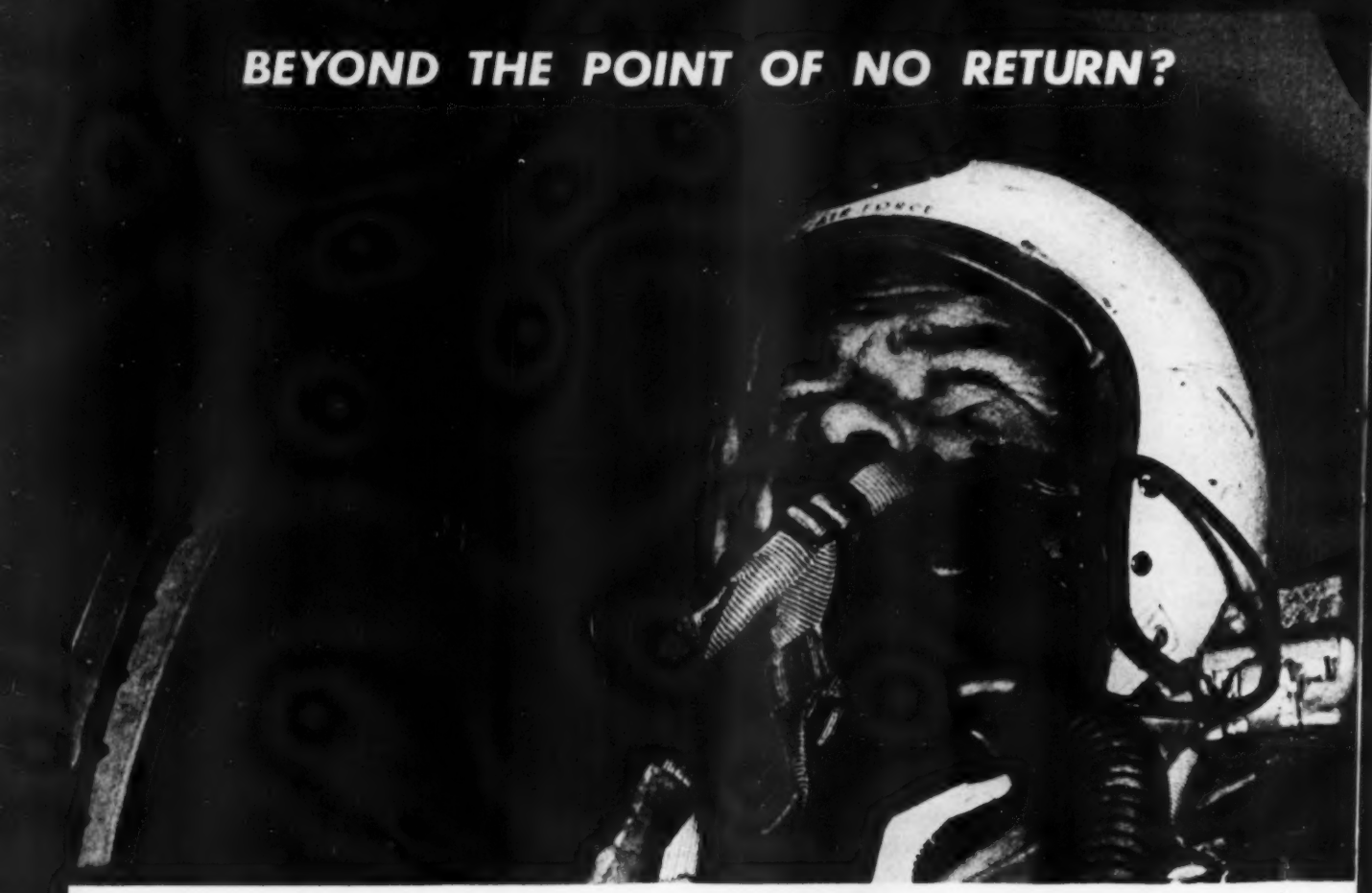
Large hydraulic actuator for supporting a fighter plane underneath the fuselage of a B-36 Bomber.

Artist's rendering shows a storing-transporting vehicle suitable for over-the-road or airborne movement. It was designed and developed by Cleveland Pneumatic's Special Products Division for a large missile manufacturer.



Complete test stand and launching facilities for an intercontinental missile can be designed, engineered, produced and erected by our Special Products Division.

BEYOND THE POINT OF NO RETURN?



WITH GENERAL ELECTRIC MASS FLOWMETER EQUIPMENT

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The range and engine efficiency of today's modern jet depend upon a precise calculation of fuel consumption. And since fuel density varies according to the type and temperature of the fuel used, measuring the number of gallons consumed is not enough. Therefore, General Electric has developed a mass flowmeter that measures the rate of fuel consumption in *pounds* rather than in gallons.

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Human Factors Approaching Maturity

By Russell Hawkes

Study of human factors in aircraft design has been forced to early maturity as an engineering science. Recent months have seen steady growth of knowledge and method leading to the day when the airplane is built around its occupant. A few bench marks are available by which progress can be measured.

An effort to hasten the day by skipping painfully slow step-by-step development is being made by the Office of Naval Research and Douglas Aircraft Co. in their integrated flight system capsule (AW, April 30, 1956, p. 54). The ONR-Douglas project combines all human factors approaches to build a control loop around the pilot in a single package providing means of surviving all but instant catastrophes, as direct hits by the enemy.

The integrated flight system capsule was developed from the merger of an ejection capsule study and a study aimed at freeing the pilot of the jobs he cannot perform well at the speeds and altitudes now being reached.

Pilot as Tactician

The Navy would like the pilot to be a tactician rather than a technologist. His airplane would be a semi-automatic functioning weapons platform, with a computer to handle flight planning control and the run on the target and to fire the weapons. There is a light computer available which is capable of doing all this. Computer design is made easier because all missions and modes of flight can be plotted from a single equation.

In his most important talent, the pilot can not be surpassed by machinery. Man is the only computer capable of logical induction. While he is a poor numerical computer and his memory for recent sensory inputs is weak, he has a good memory for generalized experience and can evaluate an unfamiliar situation in terms of this and calculate probabilities with a fair degree of accuracy. The ONR-Douglas capsule concept would save his time and energy for this one task.

Time Constant Long

Man's time constants as a sensor, computer or actuator are long. His ability to function rapidly breaks down under too many stimuli or too many things to do in too short a time.

In the capsule system, he would draw all his sensory inputs from one or two key displays and a few minor ones for occasional checks on the operation of the machine. On the basis of the information from the key displays he would make his evaluation and decision and would begin execution with a minimum number of movements.

Because the capsule can be ejected with the entire complex of pilot, computer and sensors, the prospect of survival for the pilot and the saving of costly equipment is much better than it is now.

Deceleration and air-blast have been established as major hazards in escape using standard ejection seats. The deceleration of seat and pilot after ejection at 1,000 kt. is on the order of 100G—beyond the pilot's tolerance.

Realization that airplanes are now flying faster than this indicates the need for haste in developing better escape techniques. The capsule has long been recognized as the inevitable answer. It shields the pilot from wind blast and can be streamlined to cut deceleration. The location of the expensive computing and sensing equipment in the ONR-Douglas capsule pays a survival bonus by increasing the capsule's mass and reducing deceleration.

Ride to Ground

After ejection, the pilot in the ONR-Douglas capsule would ride it all the way to the ground. Douglas engineers feel there is a net saving in weight and reliability from eliminating the personal parachute, bail-out bottles and other paraphernalia. It is also true that the pilot might not have the ability or the time to leave the capsule and open his personal parachute. The capsule can also serve as a lifeboat if it lands in the water.

Continuing efforts are being made to improve pilot survival margin, using the ejection seats which must be installed in airplanes already flying. Martin-Baker seats in British designed aircraft have a good record within the limitations inherent in ejection seats. U. S. Navy is specifying them for airplanes coming off the line.

Stability Problem

Stability has been one of the big design problems. Efforts to control tumbling and oscillating with drogue chutes and folding fins have generally been abandoned. Their failures have not unduly upset the effort, as USAF rocket sled tests at Holloman AFB and Project Smart have indicated that the problem may not be as severe as was first thought.

Still a problem is tumbling of the pilots in a free fall from great altitude after separation from the seat. The long free fall is necessary to get back to an altitude where the pilot can find an adequate oxygen supply. USAF's Aero Medical Laboratory at Wright Air Development Center has found that a body tends to spin spread-eagled in a horizontal plane.

Rate of Spin

At high altitudes, the rate of the spin may be as much as 200 rpm. Human volunteers have been spun as fast as 125 rpm. on laboratory turntables but at higher speeds there is a danger of permanent injury. A 5-ft. diameter drogue chute will inhibit the spin by holding the escapee vertical, but he must be alert to prevent a high speed pirouette from starting. Immediately after separation, the pilot may still be decelerating from the speed of the airplane. When this linear deceleration is superimposed on the spin it jostles the organs of the body and can be more dangerous than the simple spin.

Pressure Suits

Development of pressure suits to protect the body from the effects of high altitude is proceeding rapidly. Cockpits of all current and future high altitude aircraft are pressurized but emergency protection is needed against the effects of explosive decompression.

Long term protection enables the pilot to continue a mission or return at the best cruise altitude.

The Navy has developed a promising full-pressure suit which meets these requirements by inflating and keeping air pressure upon the entire body surface. Drawback of this and all other full pressure suits to date is that they are bulky and awkward. In military airplanes, the full pressure suited pilot cannot reach and operate all of the controls easily, though this factor should be less critical as black boxes take over.

Navy Mating

The Navy is studying mating full pressure suit and airplane by regrouping controls in more easily reached positions but the opportunities for this are limited for some tasks. An example is the face curtain triggered ejection seat favored by the Navy. To fire it, the pilot must put his hands above and behind his head.

USAF has concentrated on the partial pressure suit in which the helmet is pressurized with oxygen and mechanical pressure is applied to most of the rest of the body by the fabric of a skin tight suit, made yet tighter by expanding

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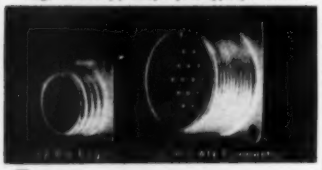
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capstan tubes which tighten laces that take up part of the fabric.

From the first T-1 suit to the present MC-4, the Air Force has made steady progress.

The MC-4 has a pressure breathing assist bladder which makes easier the unnatural work of pressure breathing.

At altitudes above 44,000 ft. it is necessary to breathe oxygen under pressure or the hydrostatic pressure of the blood prevents oxygen from passing through the walls of the alveoli of the lungs into the blood stream. The technique of breathing is reversed because pressure inside the lungs exceeds the atmospheric pressure on the outside of the body.

The oxygen flows easily into the lungs but must be expelled by a muscular effort which only becomes automatic with considerable training and may break down under emotional stress, a negative feature for combat flying.

In the MC-4, a line tied into the oxygen system downstream of the regulator carries oxygen to a bladder around the torso at the same pressure as that in the helmet. The effect is to provide counter-pressure that eases the work of breathing.

Integrated Systems

Another development is the integrated oxygen system and partial pressure suit designed by the Firewel Co. of Buffalo, N. Y., a manufacturer of women's undergarments. First financial backing for work came from Grumman Aircraft Engineering Corp. whose test pilots asked for such a unit for testing the supersonic F11F Tiger carrier-based fighter.

The Navy, having concentrated on the full pressure suit, had nothing to offer.

The full pressure suit could not be used because test flying requires too much activity on the part of the pilot.

The Firewel regulator was adopted by the Air Force shortly after the Grumman backed development began early in 1955.

The Aero Medical Laboratory at Wright Air Development Center is continuing the study and the development of the system.

Regulator Modified

The suit used with the regulator by Grumman is an Air Force T-1 modified to a Navy version of the M1A. The regulator is mounted in a back pad about two inches thick or can be modified for installation in the seat pad of an Air Force B-5 parachute. It can also be modified for use with the Martin-Baker ejection seat.

The Firewel unit serves as a breathing oxygen regulator at low altitude or with the cockpit pressurized, and controls pressure breathing and suit pressurization when the cockpit is depressurized at high altitude. Location of the regulator in the seat pads avoids duplicity of hoses and equipment that exist when there is one airplane regulator and one bailout regulator. The green-apple of the bailout system is attached to the airplane to make the actuation of the bailout bottle automatic.

Hoses in the Firewel system are of small diameter and wire reinforced to reduce the chance of breakage by wind blast.

Much attention is being given to the problem of survival in crashes by the human factors experts.

The most visible evidence of interest is the controversy over the relative merits of forward vs. aft facing seats for passengers.

Military opinion generally favors the aft facing.

Opposing View

Aviation Crash Injury Research of Cornell University, specialist in the field of crash survival, expounds the opposing view. Its position stresses the importance of capitalizing on the progressive destruction of the airplane by impact as a means of absorbing crash loads.

It argues that passengers could survive in either aft or forward facing seats if the part of the cabin surrounding them is not smashed in this progressive destruction.

If the surrounding structure is destroyed, the crash is inherently not survivable and the question of forward vs. aft facing seats is academic, Cornell argues.

The argument is based on the fact that current airplane structure is destroyed by substantially lower crash decelerations than those which the human body can withstand.

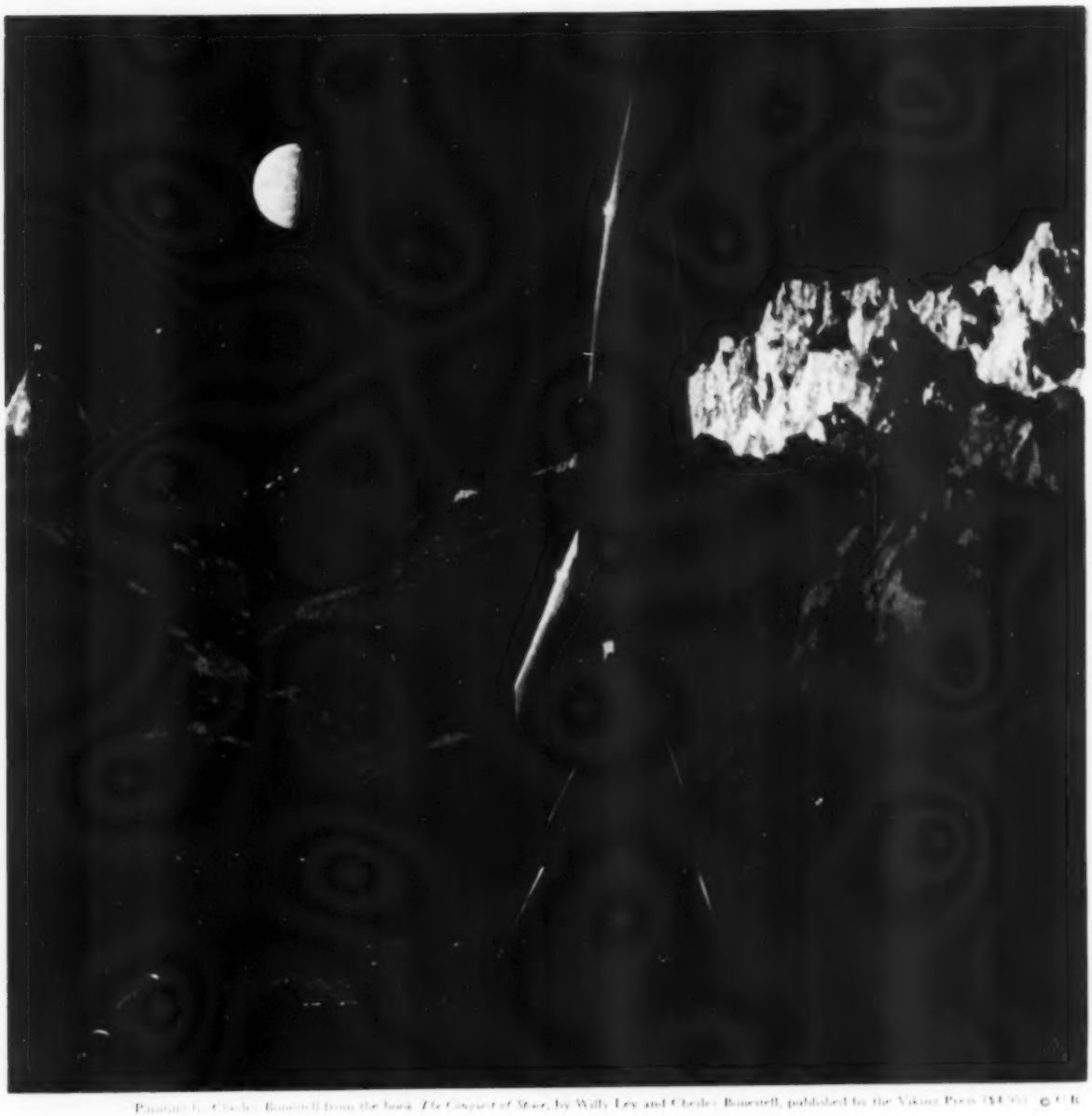
Aft Facing Opposed

A. Howard Hasbrook, director of the unit, opposes the aft facing seat because the center of gravity of seat and passenger is higher relative to the floor during the crash.

A passenger in a forward facing seat jack knifes over the seat belt lowering the CG.

This means that the impact is exerted on a shorter moment arm and the floor and tie-downs will remain intact under higher decelerations.

He concedes that if floors and tie-downs are ever designed to a yield load factor greater than the human tolerance to impact against a seat belt there would be reason to adopt the aft facing arrangement.



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by Reeves

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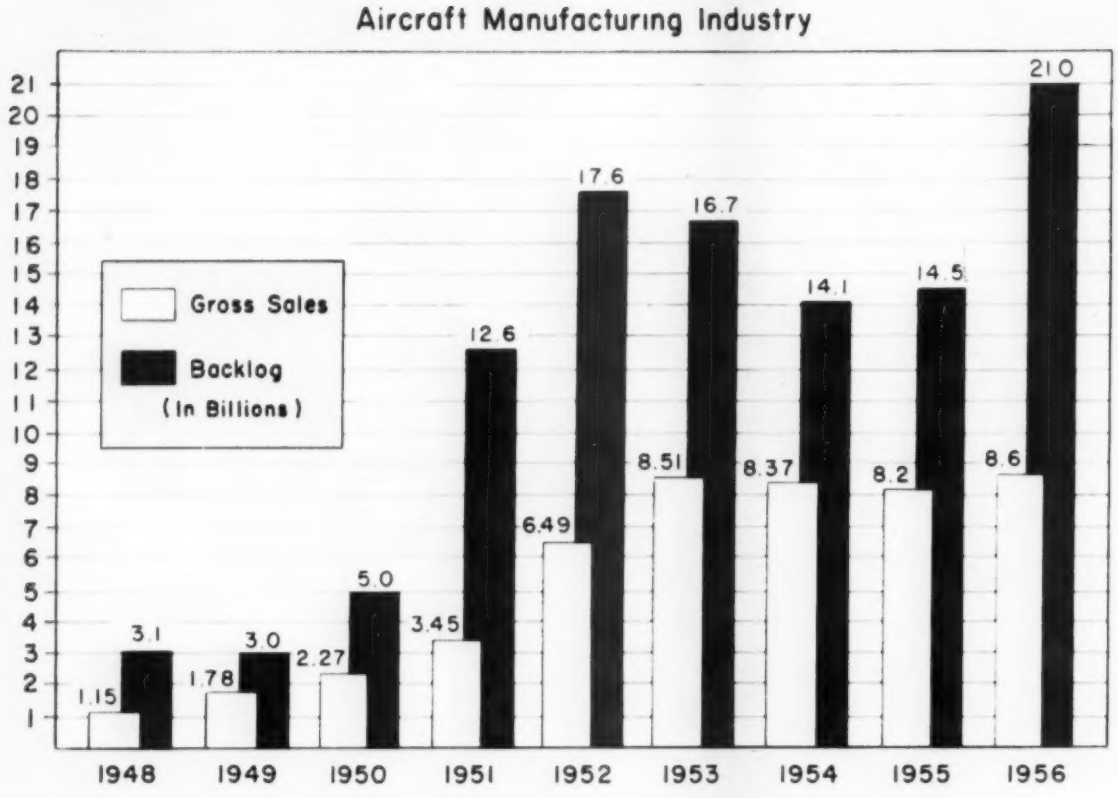
USAF C-130 Hercules transport moves down production line at Lockheed's Marietta plant.



Aircraft Industry Hits Record Sales

By Alpheus W. Jessup

In addition to record peacetime sales, the aircraft manufacturing industry gained ground last year in its struggle against burgeoning government control. Not yet measured in revisions of specific government regulations or administrative procedures, the gain was significant: broader acceptance that the profit-motivated, free-enterprise aircraft companies are a national asset for defense.

Most notable recording of the gain was the report on aircraft production costs and profits by the subcommittee of the House Armed Services Committee. It gave the aircraft industry as a whole a clean bill of health for the manner in which it operates and concluded that the industry's profits were not excessive. How far this advance can be exploited to remove or modify those controls which now tend to shackle the industry's initiative and limit its healthy growth will depend upon the industry itself.

Aircraft and missile sales for 1956 totaled $8.6 billion as predicted early in the year (AW Mar. 12, p. 194). Gross revenues were approximately $10 billion.

The aircraft industry again became the nation's largest single manufacturing industry.

More business will be done in 1957. Missile and aircraft sales, including civil purchases, will be about $9 billion. Gross manufacturing income will fall between $10 billion and $11 billion.

And there are good reasons for optimism beyond 1957:

• **Rising Backlog.** The $21 billion on the industry's order books at the beginning of 1957 was well above the highest backlog of the Korean war period. It will sustain at least the present level of business into 1960.

For the first time civil orders became a significant fraction, approximately $3 billion for airline transports and business aircraft accounting for 15% of the total backlog.

• **Budget Prospect.** Obligational authority in the Fiscal 1958 budget of the Defense Department provides $9.5 billion for new aviation procurement. Congress may well step in again to raise this figure.

Next year will almost certainly see an expansion of the budget for airpower. The "one-time" economies used to cut the 1956 budget and the stretchouts of 1957 will hardly be feasible if the U. S. is to maintain superiority over Russian airpower.

Drastic Fluctuations

With this continued high level of business there will be drastic fluctuations for individual companies. The rapid rate of technological progress creates three important conditions:

• **Rapid Obsolescence.** One company's new weapon system designed today could be made obsolete by another company's system designed tomorrow. This demands re-evaluation of existing

projects and the flexibility to change rapidly to new projects.

• **Increasing Complexity.** Necessity for always having a sure-fire retaliatory weapon compels a continual application of the latest known scientific knowledge toward development of a better weapon. This requires structures capable of withstanding hitherto unencountered forces and temperatures, and control mechanisms capable of guiding the weapon through hitherto unmet aerodynamic regimes.

• **Compression of Weapon Cycle.** Some military scientists believe that the cycle, from conception of a new weapon system until completion of its operational effectiveness, will be 10 years at most. This means that to get five years use out of a weapon system, it must be brought through research and development into quantity production of combat-ready models within five years.

Already apparent in the transition from subsonic and transonic to supersonic manned aircraft, these conditions will be pressing every manufacturer of missile weapon systems.

Uncertain Planning

Right now the problems are compounded because military planners in the Pentagon themselves are not certain what the composition of the defense forces of the future should be. Their uncertainty undoubtedly was used by the budget planners in paring the Fiscal 1958 airpower budget.

Aviation companies will need large capital resources to support research and development on the one hand and to survive the setbacks of obsolescence on the other. This fact of modern weaponry will force a trend toward larger industrial complexes in the aviation business as predicted by Editor Robert Hotz in his forecast on page 68. USAF's analysis of the impact upon aircraft companies of the new requirements is reported on page 78 by Claude Witze, military editor.

Evolution of the cost of being in the aircraft business may be illustrated by a few examples:

• **Wind tunnels.** Closed circuit 300-mph. tunnel used in developing early World War II military aircraft cost $150,000 in 1940. It costs $17.5 million today to build a Mach 3 tunnel, an absolute minimum necessity for an airframe manufacturer who wants military business during the next three years.

• **Engine testing.** In 1944, one company spent $5 million to set up a test facility for the first jet engines. A comparable tunnel to test the next series of engines will cost $17.5 million.

• **Production tools.** Special mills required to machine the spars for swept wings now costs $200,000 each. Skin for thin wing aircraft are machined from heavy plate by skin mills which cost $450,000 each.

And this is just the beginning. Not only must the aircraft industry find the materials which will provide the strength and the resistance to heat, it must also develop the methods and processes for turning these materials into aeronautical shapes and structures. What is involved in the first step into the new manufacturing era is told by Irving Stone, West Coast editor, in a report on structures beginning on page 180.

One major aircraft company recently drew up a shopping list of new facilities and equipment needed to keep its research, development and production activities up-to-date to meet competition in missile, military aircraft and civilian transport markets. The price tag was a staggering $400 million plus over the next five years. Management estimated that it might be able to squeeze $70 million out of earnings.

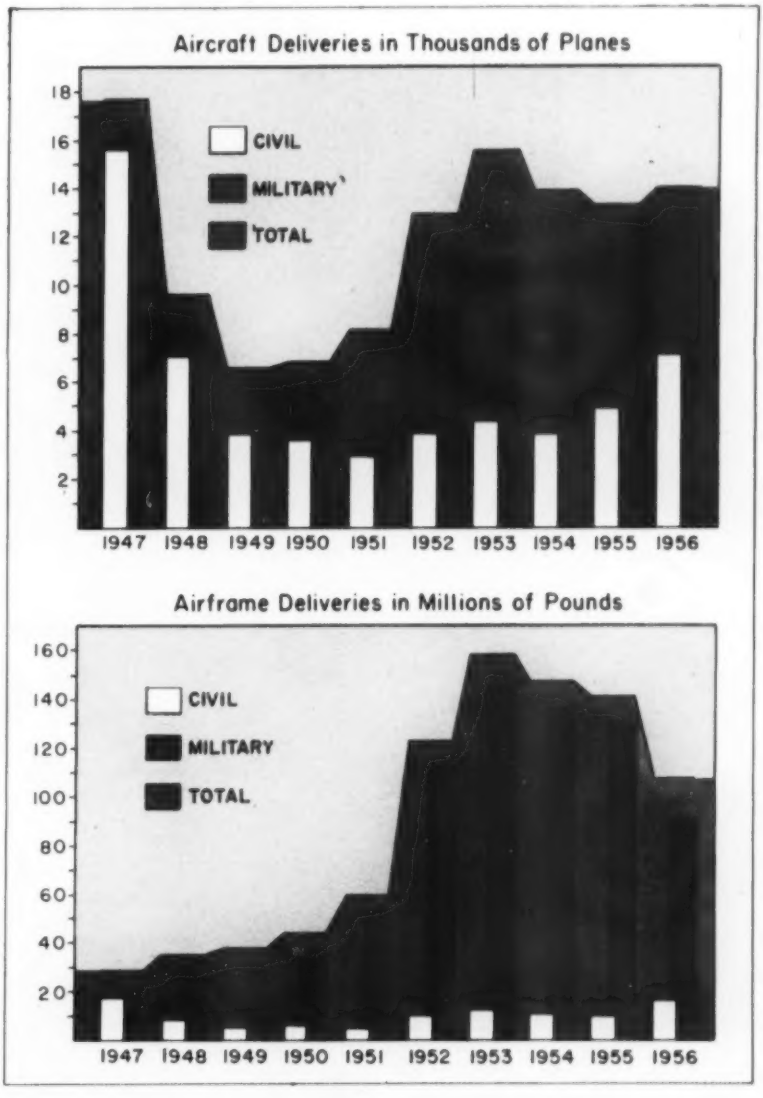
It couldn't take much more because:

• **Some part of earnings** must be paid in dividends to stock holders if the company is to attract any portion of equity capital to finance its growth.

• **Retention of more than 70%** of earnings would almost certainly bring on tax troubles. Keeping more than that share of earnings in the business is considered tax avoidance.

Where will the remainder come from? Part probably will be raised in the private money market as was done recently by Douglas Aircraft. But the bulk of what is necessary to enable this company to undertake essential development of future weapon systems will have to be furnished by government. There's no major aircraft company that isn't in a similar spot.

This is the crux of the industry's



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relation with government and public. It owes almost all of its growth and most of its future to government business. Thus, it can always expect to be in the spotlight of congressional investigation and public interest.

Price tags on modern weapon systems beckon Congressional investigation. The study of aircraft production costs and profits by the House subcommittee was launched because Representative Carl Vinson (D.-Ga.), chairman of the Committee on Armed Services, wanted to know "why it costs $8,000,000 to build" one Boeing B-52.

In its first round last year, the subcommittee pored over costs and profits of 12 prime producers of airframes. Its next target will be production costs and profits of aircraft engines, electronic systems and armament companies.

The subcommittee also will check back over "compliance" with its recommendations for improvement in administration of aviation contracts. It was particularly disturbed by the lack of uniformity in judging cost allowability of executive salaries, in charging or non-charging for the use of government-owned facilities and equipment, in technical manpower policies, in renegotiation as a process.

Renegotiation: End Near?

Renegotiation probably could be eliminated this year or by next certainly, if industry could put full pressure on Congress. Staff of the subcommittee considers renegotiation is redundant in a period of normal economic activity, and especially now that so much business is done under the selective types of contract procedures. They point out that a company with an incentive fixed price contract, for example, is still subject to the renegotiation of profits procedure. Supposedly to be rewarded for the cutting costs, it could have this good management reward taken away in renegotiation procedures.

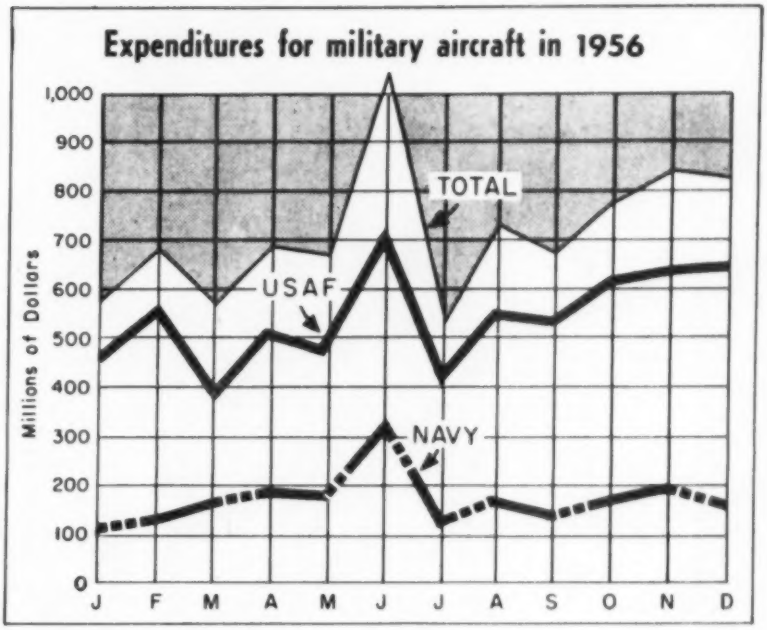
An industry spokesman who thinks renegotiation is necessary in emergency or wartime conditions, points out that competition now is strong in the defense business and this eliminates any need for broad renegotiation safeguards against defense profiteering.

Congressmen and industry agree that grasping this renegotiation nettle is difficult:

• **Politically,** a stand against renegotiation could be turned into a charge that one is favoring excessive and uncontrolled profits.

• **For some companies,** renegotiation is "a convenient umbrella". Because profits are renegotiated or are subject to it, it is considered protection from the public spotlight.

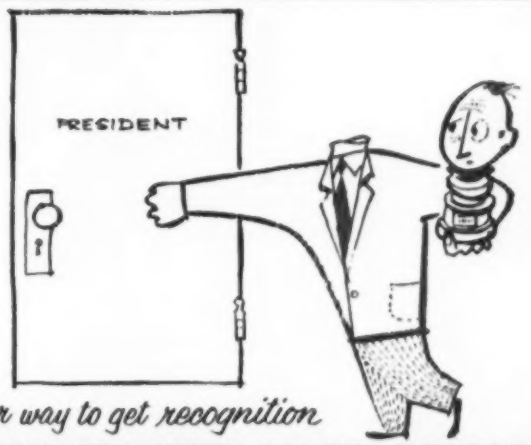
• **Renegotiation** is a crutch upon which military procurement officers can lean when defending their original procurement activities.



Also troubling management are:

• **Proprietary data.** General agreement had been reached during the past year by top military procurement officials and industry groups on the need for better protection of a company's technical data. However, in addition a new provision to ASPR 3-109, the Pentagon provided protection to unsuccessful bidders rather than successful bidders. The paragraph now says "if a contract is awarded . . . the government shall

#4 of a series*



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have the right to use the data for any purpose except as otherwise provided in the contract." This means that proprietary protection must be negotiated in every contract, with contracting officer normally adverse to any such stipulation. Industry is attempting to obtain a rewording which would specify that the government not have the right to use data except as provided in the contract.

• **Allowable costs** another area of agreement at top military-industry levels was over allowable costs, and it was hoped that a statement of accounting philosophy on allocating indirect costs would be forthcoming. Industry now fears that the Department of Defense will come out with a set of definitions on what business expenditures are not considered part of doing business. This will place most contracting on formula, with contracting offices forced to negotiate costs under narrow criteria while the potential contractor negotiates price.

• **Concurrent spare parts.** Obligation of funds for spare parts is still subject to a rule by Congress that contracts cannot be made until firm specifications and prices are established. By commitments of intent the armed services are ordering spare parts along with new equipment. But until new legislation is passed by the Congress, the aircraft industry has no protection against cancellations.

• **Working capital interests.** Industry feels that allowances, if any, for interest on borrowed money are insufficient. Rising interest rates make this a problem. On the other hand, the Armed Services Subcommittee is curious about possible delays in turning back money to the government under the incentive fixed price contracts. There was a rush of refunds to USAF and Navy last summer amounting to about $300 million. This hump, provided in the original billing price prior to redetermination, might be considered interest-free working capital.

Production and Related-Worker Employment

(in thousands)

	U. S. AIRCRAFT INDUSTRY				
	Aircraft	Acft. Engines and Parts	Props and Parts	Other Acft. Parts and Equipment	Total
1956*	$338 2	$104 2	$10 8	$79 5	$532 7
1955	330 0	94 5	9 3	80 1	513 9
1954	343 2	105 9	11 5	89 8	550 5
1953	347 8	126 5	13 2	89 3	576 8
1952	311 6	98 8	10 4	62 7	483 5
1951	232 3	63 7	7 6	38 3	341 9
1950	138 9	40 0	5 5	22 1	206 4
1949	130 8	38 6	5 5	19 8	194 7

Total Employment

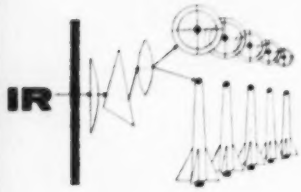
1956*	512 0	165 2	16 1	110 8	804 1
1955	482 2	145 6	13 7	109 4	750 9
1954	497 8	166 8	16 1	125 2	805 6
1953	479 1	177 3	18 0	115 9	790 3
1952	425 9	138 8	14 5	81 6	660 7
1951	313 3	90 8	10 8	48 8	463 6
1950	188 4	55 8	8 3	29 3	281 8
1949	175 3	53 5	8 2	27 0	264 1

Average Hourly Earnings of Production Workers

1956*	$2 27	$2 28	$2 26	$2 29	$2 27
1955	2 17	2 17	2 18	2 17	2 17
1954	2 08	2 09	2 09	2 07	2 08
1953	1 99	2 03	2 03	1 99	2 00
1952	1 87	1 98	2 05	1 88	1 90
1951	1 75	1 89	1 93	1 80	1 79
1950	1 622	1 696	1 743	1 698	1 644
1949	1 548	1 603	1 630	1 611	1 567

*Preliminary Figures.
SOURCE: Bureau of Labor Statistics.

INFRA-RED IS ULTRA-MODERN



In the post-war years, the development of infra-red devices has attained the dimensions of a technological breakthrough. In this period, the Electronics and Guidance Division of Aerojet-General Corp. has become the national leader in the development and manufacture of infra-red equipment.

Aerojet offers qualified engineers and scientists unparalleled opportunities in every area of the guidance and propulsion field.

Electronics Engineers
Physicists
Mechanical Engineers
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Electrical Engineers
Aeronautical Engineers
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Metallurgists
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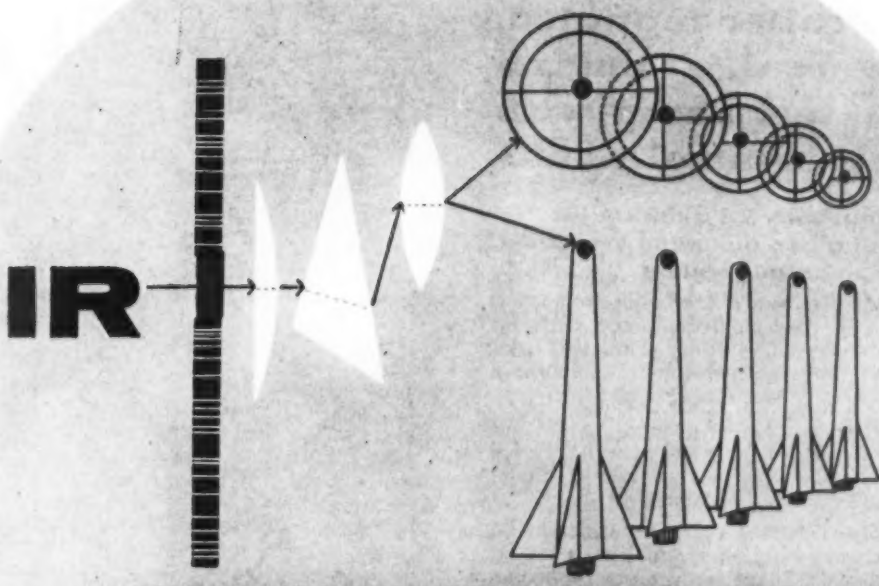

1944...RESEARCH • 1956...MASS PRODUCTION

For 13 years Aerojet-General has pioneered the research and development of infra-red devices. *Now*, Aerojet and *Aerojet alone* has perfected the high-volume production of infra-red systems for:

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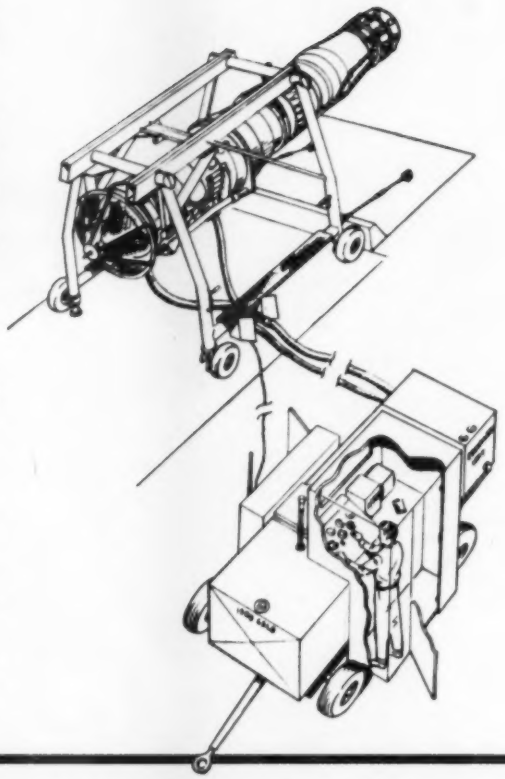
NEW!

Trailer-mounted, universal jet engine test stand with remote control house

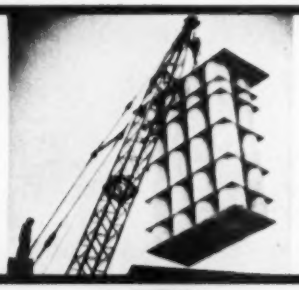


Accommodates 22 different jet engines including the latest, most powerful models

The straddle-leg design and built-in hoisting mechanism of the new Kittell-Lacy universal test stand allow mounting of jet engines from any type of transportation dolly without using any other hoisting equipment.

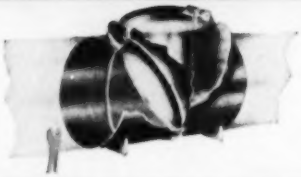
The remote control house is sound proofed and incorporates all instrumentation necessary for run-up tests, including a newly developed digital fuel flow indicator and tachometer readout.

Other similar Kittell-Lacy units are built on standard commercial trailers which permit rapid highway travel. These incorporate their own compressor and generator systems, enabling them to operate independently of support utilities.

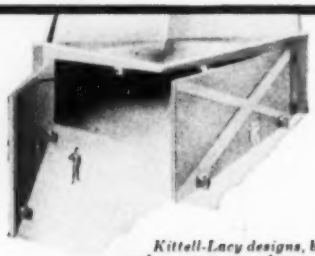


Absorption tube and resonant chamber stack treatment—Representative of several stack acoustic treatments and independent silencers available from Kittell-Lacy. These include serpentine, helical, resonant, absorption tube and insertion types to meet a wide range of air velocity and temperature. Any size or shape can be built to customer structural and performance specifications with acoustic performance and endurance guaranteed. Latest designs incorporate the amazing Basaltwool* which allows higher temperature operation.

**Thermo-Sound Division of Kittell-Lacy is the sole distributor of Basaltwool.*



Giant 12′ I.D. valve—Designed and fabricated to meet operational requirements of an air blast facility. Withstands internal pressures of 60 psi, has zero leakage, low pressure drop, and can be remotely controlled. The Kittell-Lacy design was better suited to requirements and cost far less than standard commercial valves.



Two huge 80-ton doors for a sound treated jet aircraft test cell can be opened or closed in just *30 seconds!* Special closing mechanism insures feather-light contact with the building. Designed and fabricated by Kittell-Lacy, these doors are acoustically sealed, providing a virtually air-tight enclosure. Doors are built with energy-absorbing hinges to relieve explosion pressures.

Kittell-Lacy designs, builds and guarantees performance of a complete line of test equipment for jet aircraft engines, sound-treated jet engine and airplane run-up installations, and special components and systems where standard commercial products are not available.

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Equipment Rivals Airframe in Complexity

By George L. Christian

Heavy impact of equipment on complete weapon systems is underlined by the fact that it now takes as long to develop the equipment for an aircraft as it does to develop the airframe.

Time lag is even more critical in the case of missiles. It takes longer to develop the guidance system for a modern missile (5-8 years) than it does to complete the airframe (3-5 years).

This situation is slowing the forward progress of some lines of aircraft equipment. Nonetheless, many advances were made last year in aircraft equipment. Some were due to the efforts of equipment makers, others to airframe manufacturers working under the weapon system concept.

Recent Advances

An AVIATION WEEK survey of airframe manufacturers brought out these equipment advances made during 1956. They give a good insight into what equipment progress may be expected in the immediate future.

• **Avionics:** Big strides have been made in the transition from the old black box concept to the new, integrated systems concept. Small, fighter-type aircraft are following the lead of large planes in converting from d.c. to a.c. electrical power.

• **Detection-air-to-air:** Infrared detection and range-finding devices for fighters are beginning to move out of the laboratory into aircraft.

• **Detection-submarine:** Significant advances are just being realized in airborne underwater detection gear. Operational progress in how to use the equipment is allowing operators to accomplish feats today that would have been impossible two years ago.

• **Hydraulics:** Much of the past year was spent in component testing and evaluation for high temperature applications. Class 3 hydraulic systems which will withstand 400F are now possible. But pumps, fluids and seals give marginal performance at this temperature, according to airframe makers. The low temperature limit of −65F may have to be relaxed.

• **Pneumatics:** Number of air-actuated devices is growing on airplanes already equipped with pneumatic system.

• **Cartridge actuated devices:** Use of CADs is expanding in aircraft. Their use in a plane already equipped with dual hydraulic systems may eliminate the need for compressor-powered pneumatic systems, some airplane manufacturers believe.

• **Air conditioning and pressurization:** Air cooling turbine weight is being halved while output is kept constant. Cockpit sealing techniques are improving considerably.

• **Materials:** Titanium will probably be used only as an interim structural material for fighters. Their very high speed capability portends a progression direction from aluminum to steel because of the very high skin heats expected. But titanium should prove of great value in the construction of bombers and transports flying at Mach 2-3.5.

Few, small 1956 fighter-type aircraft were built with a.c. primary electrical systems, although larger bombers have been using a.c. for several years.

Principal reason for big planes being ahead of the small in conversion to lighter a.c. electrical systems is that bombers have much more use for a.c. to power their more elaborate avionic equipments.

Comparable devices are just now appearing on fighters in quantity. Also, the constant-speed drive necessary to regulate an alternator's rpm. regardless of engine speed is a relatively bulky device which must fit between engine drive pad and alternator. In small aircraft, fitting such a drive in engine accessory space is a problem.

Some fighter designers tend towards hydraulic constant-speed drives rather than pneumatically-driven units because they believe it is more efficient to extract shaft horsepower from the engine than to bleed compressor air. They say that it may be all right to use compressor bleed air to drive accessories on multi-engine planes with multiple sources of air as on Boeing's B-52, but, on a small plane, bleeding air from its single powerplant is a serious consideration.

Hot Hydraulics

During the past year, many airframe manufacturers gingerly approached hot (400F) hydraulic systems. Efforts of hydraulic groups centered around developing serviceable 400F systems. To achieve this goal, laboratory technicians were testing many hydraulic system components for compatibility with high-temperature operation and with their own hydraulic system design.

Among components under test: pumps, hoses, fluids, packings and filters. One airframe maker is currently bringing these units out of the laboratory and is ready to put them together in a "synthetic hydraulic system" (synthetic in that it is a complete system but does not duplicate an actual system going into a plane) to see how it holds up under continuous operation at 400F.

Another aircraft manufacturer told AVIATION WEEK that he had reached his immediate goal of a serviceable 400F hydraulic system. But deficiencies exist in pumps, fluid and seals.

One hydraulic department head cited these specific high temperature tests his laboratory group is working on.

• **Hose.** Tests of Teflon-lined, high-pressure hose are giving promising results. A problem is that not all manufacturers' hose samples produce the same test results. Tests will also be conducted on all-metal hose, corrugated to attempt to give it flexibility.

Preliminary indications are that this hose is limited in flexibility, is heavy and will have fatigue problems.

• **Fluids.** Four high-temperature fluids are undergoing tests: Monsanto's OS45 and OS45-1, and Wright Field's MLO-8200 and MLO-8515. Comparisons are being made to see which has the best high temperature resistance. To date, results show that all four fluids have very similar properties.

Preliminary conclusions are that these fluids will change in lubricity, viscosity and flash point when operating continuously under high temperatures and they are susceptible to deterioration when contaminated with such products as water. Therefore high-temperature hydraulic systems will have to be designed to live with these fluids.

Cost of the Monsanto fluids, which are silicate ester base, is $20 a gallon.

• **Packings.** Two newly developed hydraulic system packing materials which are giving promising results in preliminary tests are: LS-53 fluoro-silicone Dow Corning Corporation compound (AW Jan. 14, p. 82), and Viton A fluorinated hydrocarbon material produced by E. I du Pont de Nemours & Co. Both have excellent resistance to high temperatures and to swelling and deterioration when exposed to hydraulic and other aircraft fluids.

• **Filters.** Rigimesh all-metal filters produced by Aircraft Porous Media (AW March 26, 1956, p. 73) are being tested to determine their filtering efficiency and dirt holding capacity. Since the filters are of all-metal construction, 400F creates no temperature problems.

Airframe manufacturers are divided on the need for high-pressure compressor powered pneumatic systems aboard supersonic planes.

One philosophy holds that if an aircraft incorporates a pneumatic system, this system should be used to power any ancillary devices added to the plane during its normal evolution. Rea-

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• the only simulators to meet the need for on-the-ground training in supersonic flight: famous Link jet simulators;

• the only airborne navigation systems in operational use guiding planes automatically and with unprecedented accuracy – anywhere, in any weather: GPL Doppler autonavigators.

Inertial navigation, missile guidance, photoscience, and certain nuclear power applications, are some other phases of aviation in which GPE companies are deeply and jointly involved. And while many of the products of the GPE companies – particularly in the field of aviation—serve defense needs today, the important scientific advances they embody are "plowshares" for tomorrow.

Aviation is but one industry in which GPE companies work. A brochure describing the activities of the group is available. More than a dozen basic industries are served by products resulting from GPE coordinated technologies and resources.

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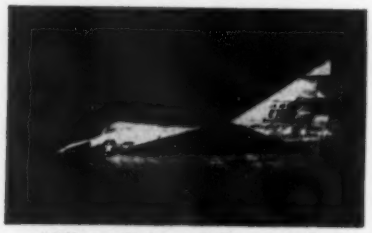

Military flight and fliers benefit immeasurably from the systems and equipments developed by GPL, Kearfott, Librascope and the other GPE companies working in aviation. Once these classified products are released for civilian use, everyone will enjoy their benefits.

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son is that the hydraulic system's primary, vital function is to power the flight control system. Any additions to this system might compromise its primary job of helping the pilot fly the ship. Therefore, it is wiser to add to the pneumatic system where such a vital job will not be compromised.

Functions which might be added to pneumatic systems include: extension of buried missile launchers, actuation of boundary layer control devices, or windshield rain removal.

Another plane maker feels that a compressor-powered pneumatic system is not required aboard modern fighters. A dual hydraulic system, it is felt, will provide the high degree of integrity needed for the powered flight control system plus the operation of such systems as landing gear and wing flap retraction and extension.

High-pressure one- or multi-shot air bottles can be used for such emergency operations, as blowing down the landing gear or applying brakes.

Cartridge actuated devices can round out ancillary system operation by salvoing external stores and ejecting crew members.

Much metallurgical work was done in laboratories last year to develop metals and finishes capable of withstanding the erosive effects of high velocity gases used in cartridge actuated devices.

Having to design jet engine bleed air systems to the higher temperature and pressure outputs of modern engine compressors has required considerable development in low pressure pneumatic system components as couplings, expansion bellows and joints, insulation.

Big strides have been made in decreasing the size of air cycle refrigeration units by developing lighter, high speed turbines. Example is a typical fighter cockpit cooling turbine whose weight was almost cut in half, from 18 lb. to 9¼ lb. Yet its output remained unchanged.

Recent developments have slowed cockpit air leakage considerably. Among them are: careful fuselage design and fabrication; more effective, inflatable canopy seals, and better sealing of the many controls coming into the cockpit.

USAF Moves Trouble Shooting Off Line Into Specialist Shop

Wright-Patterson AFB—Increasing complexity of supersonic weapon system accessories and decreasing availability of off-the-shelf airborne equipment are driving accessory trouble shooting off the flight line into specialized maintenance shops.

An official at USAF's Wright Air Development Center says, "We can't afford to have a flight line full of PhDs. . . . Current trend in the Air Force is to ignore the reason for an accessory's malfunction on the flight line—if it doesn't work, remove it and replace it—R. & R. Send it back to a specialist's shop and let him do the trouble shooting."

To offset this, a new drive is on for simplicity in weapon systems.

An AVIATION WEEK survey at WADC's Equipment Laboratory brought out these trends and developments:

• **Air transportability** for maximum mobility must be designed into all aircraft ground support equipment.

• **Unification of functions** in one ground suport vehicle.

• **Noise reduction of ground** equipment to make the flight line more livable.

• **Standardization of ground** support equipment to reduce the logistics problem. Among such items are missile trailers, jet engine handling equipment and aircraft tow bars.

• **Expansion of flight** simulator capabilities to include visual simulation and to train complete five or six man crews in all phases of a mission. Universal trainers, which can be re-programmed from one weapon system to another, are also being developed.

• **Investigation of radiant** heat to keep runways clear of snow and ice. A test section of radiant-heated runway operating at Limestone AFB, Me., suggests that a radiant heating system can pay for itself in 8-10 years.

• **Design of an aeronautical** series of wrenches, small and slim enough to fit into the hard-to-get-at corners of a tightly-packed airframe.

Ready Items

Among new equipment in or going into service are:

• **Portable runway lighting** system including all lights, cables, transformers and control equipment. Being completely water-proof, it can be set up on the ground without special conduit or housing, be picked up and moved easily to new air bases.

• **Helicopter-transportable** crash fire fighting equipment which will be delivered to the Air Force this spring.

An example of consolidation of several services in a single vehicle is the MA-3 multi-purpose servicing unit made by Beech Aircraft and the earlier MA-1 made by Consolidated Diesel Electric Corp. (AW Dec. 27, 1954, p. 55).

Services furnished by the MA-3 unit:

• **High pressure** (3,500 psi.) air for

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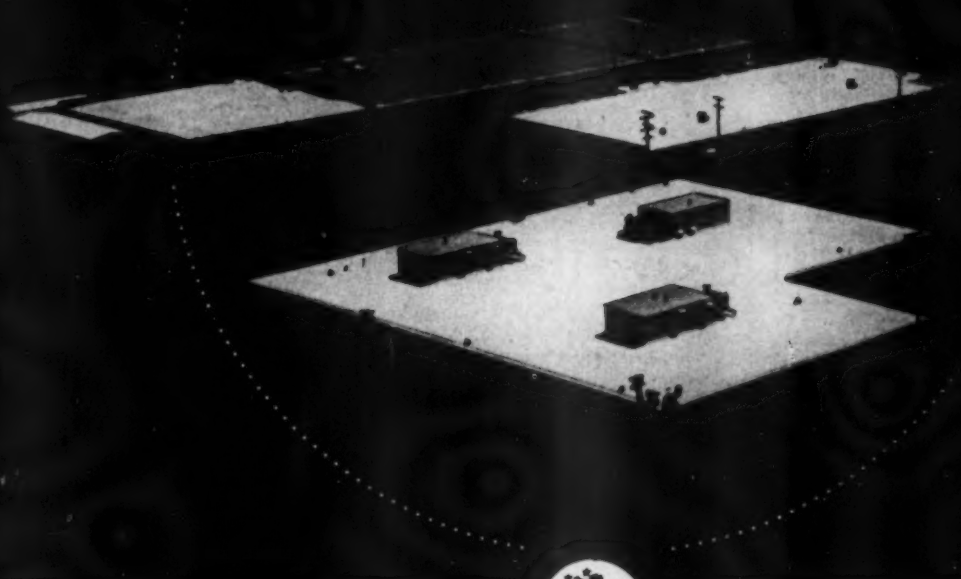

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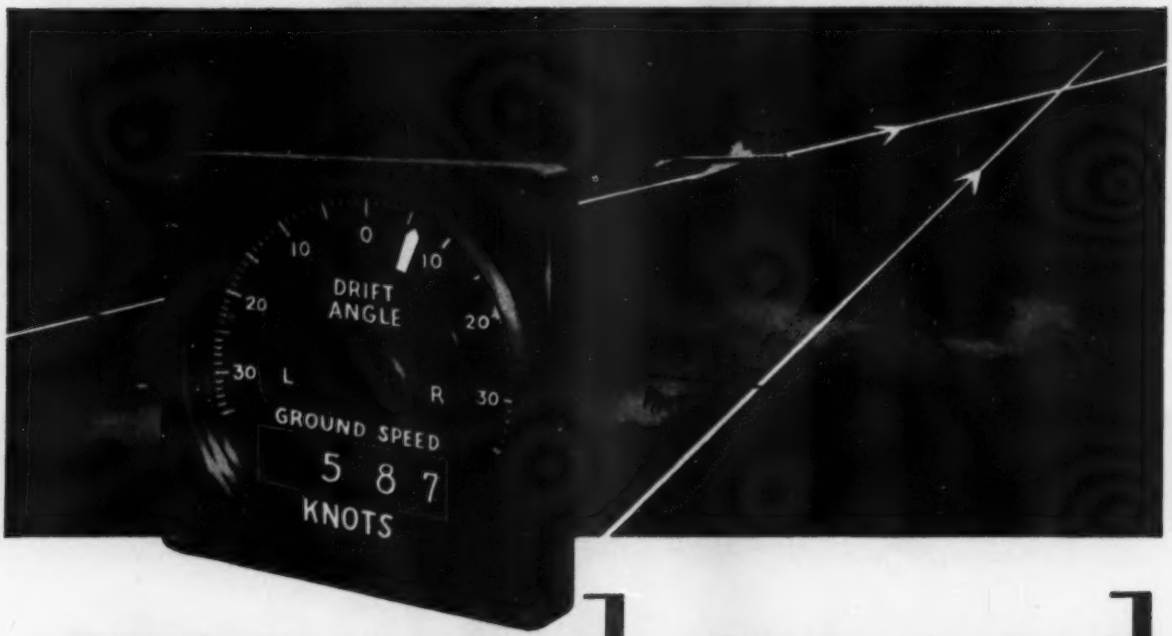
The systems were developed for the Air Force (WADC). They are the result of an achievement comparable in magnitude to the breaking of the sound barrier: GPL's harnessing of the Doppler-effect to air navigation.

The benefits of these GPL systems extend to every area of flight. Their vast potential has just begun to be explored. Already, air lines awaiting delivery of sleek, high speed jet liners are anticipating availability of the equipment and counting on it for safe, direct and economical global operation.



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charging landing gear struts and hydraulic system accumulators.

• **Low pressure** (50 psi.) air to start jet engines.

• **Air conditioning** to cool crew area and avionic equipment. The self propelled vehicle also serves as a tow.

Omitted from the MA-3 are oxygen and fuel servicing gear. Because both are potentially dangerous, Air Force thinks they should be taken care of separately.

Simplicity & Standardization

Conflicting requirements show up in some ground handling equipment. Missile-carrying trailers, for instance, must be custom-fitted to the missile being transported. But the USAF wants to standardize trailers to lower cost and simplify maintenance and supply.

One solution is to standardize the chassis and tailor only the superstructure to the missile.

Airframe manufacturers have been designing the engine handling equipment for their own planes, causing considerable duplication and unnecessary expense. The Air Force called three airplane makers together with this result: one engine handling device which will service several different fighter aircraft.

WADC also developed a universal tow bar which can be used with 15 different aircraft. A later version is being tested which will handle 25 different types, both USAF and Navy.

USAF is seeking a landing barrier which will be less of an emergency device and more of a routine aid.

The USAF wants to get rid of the cumbersome anchor chain method. The chain is heavy and takes a lot of man power to reset it after use. Replacing the chain is slow, which means that several aircraft cannot use it in quick succession.

New system may use friction devices on either side of the runway to produce tension automatically on an interconnecting cable which is picked up by landing aircraft to slow it. The device requires no manpower to reset and it can be quickly disengaged from one plane and reset for the next.

Circling lights, a new development in runway lighting, are being designed to assist jet landings. Because they usually approach air fields at higher altitudes and circle at greater distances from the runway than piston pilots, jet airmen need special lights to help them identify runways.

Tentative plan is to install circling lights in a line 25 ft. outside each row of existing runway lights. Probable spacing will be one every 1,000 ft.

A "jury-rigged" set is now installed on the East-West runway at Wright Field, according to WADC. A fully-developed set, being produced by the AGA division of Elastic Stop Nut Corporation of America, will be delivered soon.

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Aero Design & Engineering Co.	Bethany, Okla.	65,000	850	.....	.....	.....	.....	1,500,000	126,000		
Aerojet-General Corp.	Azusa, Calif.		9,600	$144,467,281	3,433,000	800,000,000		5,000,000	Production & R & D		
Beech Aircraft Corporation	Wichita, Kansas	1,744,000	7,049	74,538,948	3,331,327	104,782,843	$809,147	450,000	100,000		
Bell Aircraft Corp.	Buffalo 5, N. Y.	2,692,552	15,480	156,200,000[2]	4,800,000[2]	177,350,950	$3,276,603[1]	.....	.....	450,000	56,000
Bell Helicopter Corp.	Ft. Worth, Texas	696,000	7,300	.....	.....	.....	.....	.....	40,000		
Bendix Aviation Corp.	Detroit, Mich.	7,887,000	47,456	878,055,632[2]	24,278,263[2]	544,000,000[2]					
Boeing Airplane Co.	Seattle, Wash.	9,196,000	.....	871,628,000[2]	22,971,000[2]	3,230,000,000[2]					
Cessna Aircraft Co.	Wichita, Kansas	1,187,720	5,189	84,902,734	4,155,534	62,580,000	$950,442	2,952,234	204,080	886,444	85,790
Chance Vought Aircraft Inc.	Dallas, Texas	2,535,000	14,000	77,208,611[1]	1,984,838[1]	490,400,000[2]	40¢ quarterly				
Curtiss-Wright Corp.	Wood-Ridge, N. J.										
Douglas Aircraft Co., Inc.	Santa Monica, Calif. El Segundo, Calif. Long Beach, Calif. Tulsa, Okla.	16,200,000[2]	81,511	1,073,515,000	23,202,000	2,232,000,000	$33,202,000				
Fairchild Engine & Airplane Corp. **Aircraft Division** **Engine Division** **Guided Missile Division** **Stratos Division** **Electrotechnics Division** **Armalite Division**	Hagerstown, Md. Hagerstown, Md. Deer Park, N. Y. Wyandanch, N. Y. Bay Shore, N. Y. Costa Mesa, Calif. Hollywood, Calif.	2,875,000	11,909	107,454,000[2]	1,374,000[2]	187,000,000[2]					
Firestone Tire & Rubber Co. **Guided Missile Division**	Los Angeles, Calif.	.....	1,800	Reported in corporate statement							
General Dynamics Corp., **Convair Division** **Convair General Office** **Convair-San Diego** **Convair-Astronautics** **Convair-Pomona** **Convair-Fort Worth** **Convair-Daingerfield**	San Diego, Calif. San Diego, Calif. San Diego, Calif. San Diego, Calif. Pomona, Calif. Fort Worth, Tex. Daingerfield, Tex.	10,566,990[1] ..... 4,628,523 Building 1,466,750 4,341,673 129,134	70,174[2] 264 32,049 6,904 5,049 25,863 335								
General Electric Co., **Aircraft Gas Turbine Division** **Missile & Ordnance Systems**	Evendale, Ohio Philadelphia, Pa.	4,746,000 1,000,000[2]	22,000 4,000[2]	Reported in corporate statement							
General Motors Corp., **Allison Division**	Indianapolis, Ind.	3,260,282	18,000	Reported in corporate statement			.....	.....	.....	.....	813,800
Goodyear Aircraft Corp.	Akron, Ohio Litchfield Park, Ariz.	.....	.....	Reported in corporate statement							
Grumman Aircraft Engineering Corp.	Bethpage, N. Y. Peconic River, N. Y.	3,018,884 535,927	11,613 1,880	140,405,243[1]	6,037,977[1]	357,000,000[2]					
Hiller Helicopters	Palo Alto, Calif.	184,000	878								
Hughes Aircraft Co.	Culver City, Calif.	.....	24,000	300,000,000[2]	.....	585,000,000[2]					
The Kaman Aircraft Corp.	Bloomfield, Conn.	204,000	1,150	.....	.....	.....	40¢/share				
Lockheed Aircraft Corporation	Burbank, Calif.	14,000,000	61,032	750,000,000[2]	10,844,000[2]	1,580,000,000[2]					
The Martin Company	Baltimore, Md.	5,990,888	26,000	228,766,424[1]	7,311,022[1]	.....	$1.60 + 5% stock				
McDonnell Aircraft Corp.	St. Louis, Mo.	2,761,121	20,377	186,204,381[3]	6,751,569[2]	.....	$740,150 + 3% stock				
North American Aviation, Inc. **Atomics International** **Rocketdyne** **Autonetics** **Missile Development Division** **Columbus Division** **Fresno Division** **Los Angeles Division**	International Airport, Los Angeles Canoga Park, Calif. Canoga Park, Calif. Downey, Calif. Downey, Calif. Columbus, Ohio Fresno, Calif. International Airport	11,000,000	73,000	913,981,913[2]	28,760,962[2]	1,285,000,000[2]	$13,224,877				
Northrop Aircraft, Inc.	Hawthorne, Calif.	3,305,000	23,800	322,513,290	4,965,071	251,000,000					
Piper Aircraft Corp.	Lock Haven, Pa.	373,115	1,685	25,083,705	2,553,593	6,027,050	$704,677	294,000	33,211	375,000	10,000
Republic Aviation Corporation **Guided Missile Division**	Farmingdale, N. Y. Mineola, N. Y.	2,700,000 65,000	18,000	232,370,178[2]	4,814,705[2]	400,000,000[2]	$1.50[1]/share	.....	.....	4,200,000	
The Ryan Aeronautical Co.	San Diego, Calif.	1,000,000	7,979	45,000,000	1,250,000	75,000,000					
Temco Aircraft Corp. **Dallas Division**	Dallas, Texas	2,072,900[2]	10,764[2]	61,196,203[1,2]	2,089,189[1,2]	75,867,000[1,2]	$1,257,623	.....	200,000	1,500,000	100,000
United Aircraft Corp. **Pratt & Whitney Aircraft Division** **Hamilton Standard Division** **Sikorsky Aircraft Division**	E. Hartford, Conn. E. Hartford, Conn. Windsor Locks, Conn. Bridgeport, Conn.	10,000,000[2]	60,000	668,007,809[1,2]	28,170,358[1,2]	2,125,000,000[1,2]					
Vertol Aircraft Corp.	Morton, Pa.	898,836	5,326	.....	.....	116,000,000	15% stock				
Westinghouse Electric Corp. **Aviation Gas Turbine Division** **Air Arm Division** **Electronics Division** **Ordnance Division** **Small Motors — Aviation Division**	Kansas City, Mo. Baltimore, Md. Baltimore, Md. Baltimore, Md. Lima, Ohio	5,125,000[2]	12,860								

[1] First nine months 1956
[2] Total all divisions
[3] Approximate
[4] Estimated
[5] Fiscal year ending June 1956
[6] Fiscal year ending Sept. 1956

Source: Industry reports to AVIATION WEEK

U.S. Missiles

	GENERAL				STATUS				AIRFRAME					POWERPLANT			
Category	Missile name	Military designation	Cognizant service branch	Prime contractor	Research	Development	Production	Service use	Manufacturer	Overall length, less booster, ft.	Overall span, wings or fins, ft.	Body diameter, ft.	Launching wt., less booster, lb.	Manufacturer	Number of engines	Engine designation	Rated thrust, lb.
Air-to-air	Ding-Dong	.....	USAF	Douglas	√	√	...	...	Douglas	.....	.....	.....	.....	NAA	1	1 rpr.	.....
	Falcon	GAR-1	USAF	Hughes	...	...	√	√	Hughes	6	2	0.5	100	Thiokol	1	M-58 spr.	.....
	Sidewinder	XAAM-N-7	BuOrd	Philco	...	...	√	√	GE/Philco	9	.....	.....	155	.....	1	spr.	.....
	Sparrow 1	XAAM-N-2	BuAer	Sperry	...	...	√	√	Douglas	12	.....	.....	300	Aerojet	1	spr.	.....
	Sparrow 2	XAAM-N-3	BuAer	Douglas	...	√	√		Douglas	.....	.....	.....	.....	.....	1	spr.	.....
	Sparrow 3	XAAM-N-4	BuAer	Raytheon	√	√			.....	.....	.....	.....	.....	.....	1	spr.	.....
Air-to-surface	Bullpup	XASM-N-7	Navy	Martin	...	√			Martin	11	.....	1	.....	.....	...	spr.	.....
	Rascal	GAM-63	USAF	Bell	...	√	√		Bell	30	.....	4	.....	Bell	3	lpr.	12,000
Air-to-underwater	Petrel	Mk. 3 Mod. 0	BuOrd	F'child GMD	...	...	...	√	F'child GMD	24	13	2	3,800	F'child ED	1	J44 tj.	1,050
Surface-to-air	Bomarc	IM-99	USAF	Boeing	...	√	√		Boeing	.....	.....	.....	8,500	Marquardt	2	rj.	.....
	Hawk	.....	ArmyOrd	Raytheon	...	√	√	...	Northrop	10	.....	0.8	.....	.....	1	spr.	.....
	Nike-Ajax	XSAM-A-25	ArmyOrd	West. Elec.	...	...	√	√	Douglas	20	.....	1	1,000	Aerojet/Bell	1	lpr.	2,000
	Nike-Hercules	.....	ArmyOrd	West. Elec.	...	√	√		Douglas	.....	.....	.....	.....	.....	1	lpr.	.....
	Talos	XSAM-N-6	BuOrd	Bendix	...	√	√		McDonnell	.....	.....	.....	.....	McDonnell	1	rj.	.....
	Tartar	.....	BuOrd	Convair	...	√	√	...	Convair	.....	.....	.....	.....	.....	1	spr.	.....
	Terrier 1	XSAM-N-7	BuOrd	Convair	...	...	√	√	Convair	13	.....	.....	1,000	Kellogg	1	spr.	.....
	Terrier 2	.....	BuOrd	Convair	...	√	√	...	Convair	.....	.....	.....	.....	.....	1	spr.	.....
Surface-to-surface	Atlas	WS-107A-1	USAF	Convair	√	√		...	Convair	65	.....	.....	.....	NAA	1	lpr.	135,000
	Corporal	XSSM-A-17	ArmyOrd	JPL	...	...	√	√	Firestone	45	....	2.5	.....	Ryan	1	lpr.	.....
	Dart	XSSM-A-23	ArmyOrd	ADC	...	...	√		Utica-Bend	5	3	0.7	.....	Grand Cent.	1	monochem spr.	.....
	Honest John	M-31	ArmyOrd	Douglas	...	...	√	√	Douglas	27	8	2.5	8,000	Hercules	1	spr.	.....
	Jupiter	.....	ArmyOrd	Chrysler	√	√	...	...	Chrysler	.....	.....	.....	.....	NAA	1	lpr.	135,000
	Lacrosse	XSSM-A-12	ArmyOrd	Cornell	√	√	...	...	Martin	.....	.....	.....	.....	Thiokol	1	spr.	.....
	Little John	XM-47	ArmyOrd	Emerson	...	√	√		Douglas	12	.....	1.0	.....	.....	1	spr.	.....
	Matador	TM-61A	USAF	Martin	...	...	√	√	Martin	39	29	4.5	12,000	Allison	1	J33-A-37 tj.	4,600
	Navaho	SM-64	USAF	NAA	...	√	...	...	NAA	.....	.....	.....	.....	NAA	2	rj.	.....
	Polaris	.....	Navy	Lockheed	√	√	...	...	Lockheed	.....	.....	.....	.....	Aerojet	...	lpr.	.....
	Redstone	XSSM-A-14	ArmyOrd	Chrysler	...	√	√	...	Chrysler	60	13	6	.....	NAA	1	lpr.	.....
	Regulus 1	SSM-N-8a	BuAer	Vought	...		√	√	Vought	30	21	.....	12,000	Allison	1	J33-A-18A tj.	4,600
	Regulus 2	XFSSM-N-9	BuAer	Vought	...	√	√	...	Vought	.....	.....	.....	.....	.....	.....	.....	.....
	Sergeant	.....	ArmyOrd		...	√	√	...	.....	.....	.....	.....	.....	.....	1	spr.	.....
	Snark	SM-62	USAF	Northrop	...	√	√	...	Northrop	69	42	.....	.....	P&WA	1	J57 tj.	11,000
	Thor	WS-315A	USAF	Douglas	√	√	...	...	Douglas	.....	.....	.....	.....	NAA	1	lpr.	.....
	Titan	WS-107A-2	USAF	Martin	√	√	...	...	Martin	.....	.....	.....	.....	Aerojet	...	lpr.	.....
	Triton	XSSM-N-2	BuOrd	McDonnell	...	√			McDonnell	45	....	5.0	20,000	McDonnell	2	rj.	.....

Abbreviations:
ADC Aerophysics Development Corp.
ArmyOrd Army Ordnance
BuAer Navy Bureau of Aeronautics
BuOrd Navy Bureau of Ordnance
Comm./hom. Command with radar homing
GE General Electric
ICBM Intercontinental ballistic missile
IRBM Intermediate range ballistic missile
JPL Jet Propulsion Lab, Cal Tech
lpr Liquid-propellant rocket
NAA North American Aviation, Inc.
NOTS Naval Ordnance Test Station
P&W

U.S. Missiles

	GENERAL				STATUS				AIRFRAME			
Category	Missile name	Military designation	Cognizant service branch	Prime contractor	Research	Development	Production	Service use	Manufacturer	Overall length, less booster, ft.	Overall span, wings or fins, ft.	
Air-to-air	Ding-Dong	.....	USAF	Douglas	√	√	...	...	Douglas	.....	.....	
	Falcon	GAR-1	USAF	Hughes	...	...	√	√	Hughes	6	2	
	Sidewinder	XAAM-N-7	BuOrd	Philco	...	...	√	√	GE/Philco	9	.....	
	Sparrow 1	XAAM-N-2	BuAer	Sperry	...	...	√	√	Douglas	12	.....	
	Sparrow 2	XAAM-N-3	BuAer	Douglas	...	√	√	...	Douglas	.....	.....	
	Sparrow 3	XAAM-N-4	BuAer	Raytheon	√	√	...	...	.....	.....	.....	
Air-to-surface	Bullpup	XASM-N-7	Navy	Martin	...	√	...	...	Martin	11	.....	
	Rascal	GAM-63	USAF	Bell	...	√	√	...	Bell	30	.....	
Air-to-underwater	Petrel	Mk. 3 Mod. 0	BuOrd	F'child GMD	...	...	...	√	F'child GMD	24	13	
Surface-to-air	Bomarc	IM-99	USAF	Boeing	...	√	√	...	Boeing	.....	.....	
	Hawk	.....	ArmyOrd	Raytheon	...	√	√	...	Northrop	10	.....	
	Nike-Ajax	XSAM-A-25	ArmyOrd	West. Elec.	...	...	√	√	Douglas	20	.....	
	Nike-Hercules	.....	ArmyOrd	West. Elec.	...	√	√	...	Douglas	.....	.....	
	Talos	XSAM-N-6	BuOrd	Bendix	...	√	√	...	McDonnell	.....	.....	
	Tartar	.....	BuOrd	Convair	...	√	√	...	Convair	.....	.....	
	Terrier 1	XSAM-N-7	BuOrd	Convair	...	...	√	√	Convair	13	.....	
	Terrier 2	.....	BuOrd	Convair	...	√	√	...	Convair	.....	.....	
Surface-to-surface	Atlas	WS-107A-1	USAF	Convair	√	√	...	...	Convair	65	.....	
	Corporal	XSSM-A-17	ArmyOrd	JPL	...	...	√	√	Firestone	45	.....	
	Dart	XSSM-A-23	ArmyOrd	ADC	...	...	√	...	Utica-Bend	5	3	
	Honest John	M-31	ArmyOrd	Douglas	...	...	√	√	Douglas	27	8	
	Jupiter	.....	ArmyOrd	Chrysler	√	√	...	...	Chrysler	.....	.....	
	Lacrosse	XSSM-A-12	ArmyOrd	Cornell	√	√	...	...	Martin	.....	.....	
	Little John	XM-47	ArmyOrd	Emerson	...	√	√	...	Douglas	12	.....	
	Matador	TM-61A	USAF	Martin	...	...	√	√	Martin	39	29	
	Navaho	SM-64	USAF	NAA	...	√	...	...	NAA	.....	.....	
	Polaris	.....	Navy	Lockheed	√	√	...	...	Lockheed	.....	.....	
	Redstone	XSSM-A-14	ArmyOrd	Chrysler	...	√	√	...	Chrysler	60	13	
	Regulus 1	SSM-N-8a	BuAer	Vought	...	...	√	√	Vought	30	21	
	Regulus 2	XFSSM-N-9	BuAer	Vought	...	√	√	...	Vought	.....	.....	
	Sergeant	.....	ArmyOrd	.....	...	√	√	...	.....	.....	.....	
	Snark	SM-62	USAF	Northrop	...	√	√	...	Northrop	69	42	
	Thor	WS-315A	USAF	Douglas	√	√	...	...	Douglas	.....	.....	
	Titan	WS-107A-2	USAF	Martin	√	√	...	...	Martin	.....	.....	
	Triton	XSSM-N-2	BuOrd	McDonnell	...	√	...	...	McDonnell	45	.....	

Abbreviations:
ADC—Aerophysics Development Corp.
ArmyOrd—Army Ordnance
BuAer—Navy Bureau of Aeronautics
BuOrd—Navy Bureau of Ordnance
Comm./nam.—Command with radar homing
GE—General Electric
ICBM—Intercontinental ballistic missile
IRBM—Intermediate range ballistic missile
JPL—Jet Propulsion Lab. Cal Tech

NORTH AMERICAN X-10

AIRFRAME				POWERPLANT				GUIDANCE		PERFORMANCE		REMARKS
Overall length, less booster, ft.	Overall span, wings or fins, ft.	Body diameter, ft.	Launching wt., less booster, lb.	Manufacturer	Number of engines	Engine designation	Rated thrust, lb.	Manufacturer	Type of guidance	Maximum Mach number	Maximum range, nmi.	Remarks
...	.....	.....	.....	NAA	1	1 lpr.	.....	Hughes	.....	.....	.....	Nuclear warhead
6	2	0.5	100	Thiokol	1	M-58 spr.	.....	Hughes	Radar hom.	.....	.....	GAR-1D is latest model
9	.....	.....	155	.....	1	spr.	.....	GE/Philco	Infra-red	.....	.....	Developed at NOTE
3	.....	.....	300	Aerojet	1	spr.	.....	Sperry	Beam rider	2.5	.....	In 6th & 7th Fleet use
...	.....	.....	.....	.....	1	spr.	.....	.....	.....	.....	.....	
...	.....	.....	.....	.....	1	spr.	.....	Raytheon	Radar hom.	.....	.....	
1	.....	1	.....	.....	...	spr.	.....	.....	.....	.....	.....	Test vehicle for Bulldog
0	.....	4	.....	Bell	3	lpr.	12,000	Federal	.....	1.5	100	"Shrike" was test vehicle
4	13	2	3,800	F'child ED	1	J44 tj.	1,000	F'child GMD	Radar hom.	0.7	.....	Out of production
...	.....	.....	8,500	Marquardt	2	rj.	.....	.....	Comm./hom.	2.5	200	
0	.....	0.8	.....	.....	1	spr.	.....	Raytheon	Radar hom.	.....	.....	
0	.....	1	1,000	Aerojet/Bell	1	lpr.	2,000	West. Elec.	Beam rider	.....	25	Deployed in U.S.A.
...	.....	.....	.....	.....	1	lpr.	.....	.....	.....	.....	.....	Was called Nike B
...	.....	.....	.....	McDonnell	1	rj.	.....	.....	.....	.....	.....	Also XIM-70 for USAF
...	.....	.....	.....	.....	1	spr.	.....	.....	.....	.....	.....	Destroyer armament
3	.....	.....	1,000	Kellogg	1	spr.	.....	Reeves	Beam rider	2.5	10	
...	.....	.....	.....	.....	1	spr.	.....	Sperry	Beam rider	2.5	20	Frigate armament
5	.....	.....	.....	NAA	1	lpr.	135,000	.....	.....	.....	.....	Booster: 2 x 100,000 lpr.
5	.....	2.5	.....	Ryan	1	lpr.	.....	Gilfillan	Command	.....	100	Deployed in Europe
5	3	0.7	.....	Grand Cent.	1	smokeless spr.	.....	Wagner	Optical	.....	.....	Anti-tank weapon
7	8	2.5	6,000	Hercules	1	spr.	.....	.....	Unguided	.....	15	Deployed in Europe, Japan
...	.....	.....	.....	NAA	1	lpr.	135,000	Ford Inst.	Inertial	.....	1,500	Army IRBM
...	.....	.....	.....	Thiokol	1	spr.	.....	Federal	Command	.....	8	
?	.....	1.0	.....	.....	1	spr.	.....	.....	Unguided	.....	.....	
9	29	4.5	13,000	Allison	1	J33-A-37 tj.	4,600	.....	.....	0.9	.....	Also TM-61B, TM-61C
...	.....	.....	.....	NAA	2	rj.	.....	NAA	Inertial	3.0	5,000	Booster: 1 NAA lpr. pack
...	.....	.....	.....	Aerojet	...	lpr.	.....	GE	Stell./Iner.	...	1,500	Navy IRBM
?	12	6	.....	NAA	1	lpr.	.....	Ford Inst.	Inertial	.....	300	Warhead separates
?	21	.....	12,000	Allison	1	J33-A-18A tj.	4,600	.....	.....	0.9	.....	Flight test veh.: SSM-N-8
...	.....	.....	.....	.....	...	.....	.....	Sperry	.....	.....	.....	Supersonic
...	.....	.....	.....	.....	1	spr.	.....	.....	.....	.....	.....	Tactical missile
?	42	.....	.....	P&WA	1	J57 tj.	11,000	Northrop	Stell./Iner.	0.9	5,000	To join SAC next year
...	.....	.....	.....	NAA	1	lpr.	.....	AC Elec.	.....	.....	1,500	USAF IRBM
...	.....	.....	.....	Aerojet	...	lpr.	.....	Arma	Inertial	.....	5,000	USAF ICBM
?	.....	5.0	20,000	McDonnell	2	rj.	.....	.....	.....	.....	.....	

missile
ic missile
ach

lpr—Liquid-propellant rocket
NAA—North American Aviation, Inc.
NOTS—Naval Ordnance Test Station

P&WA—Pratt & Whitney Aircraft Division
rj—Ramjet
spr—Solid-propellant rocket

Stell./Iner.—Stellar-inertial
tj—Turbojet
USAF—United States Air Force

U.S. Military Aircraft

Manufacturer	Military Designation	Military name	Primary mission	Number in crew	DIMENSIONS: Overall span, ft.	Overall length, ft.	Overall height, 3-pt., ft.	Gross wing area, sq. ft.	WEIGHTS: Weight empty, lb.	Normal gross wt., lb.	Maximum gross wt., lb.	POWERPLANT: Number, manufacturer, model and max. rating
Aero Design Engineering Co. *Bethany, Okla.*	L-26B	Commander	Light Transport	7	44' 0"	35' 5"	14' 9"	242	4,145	6,000	.....	2 Lyc. GO-480-D1A @ 275 h
	L-26C	Commander	Light Transport	7	44' 0"	35' 5"	14' 9"	242	4,330	7,000	.....	2 Lyc. GSO-480-A1A6 @ 340
Beech Aircraft Corp. *Wichita 1, Kan.*	L-23D	.....	Lt. Trans.	6	45' 3"	31' 6"	11' 4"	277	4,881	7,000	.....	2 Lyc. O-480-1 @ 295 hp.
	L-23E	.....	Lt. Trans.	6	45' 3"	31' 6"	11' 4"	277	4,015	6,300	.....	2 Lyc. GSO-480-A1A6 @ 340
	T-34A	Mentor	Trainer	2	32' 10"	25' 11"	9' 7"	178	2,170	2,900	.....	1 Con. O-470-13 @ 225 hp.
	Model 73	Jet Mentor	Jet Trainer	2	32' 9"	30' 0"	9' 9"	178	3,034	4,300	.....	1 Con. J69-T-9 @ 920 lb. t.
Boeing Airplane Co. *Seattle, Wash.*	B-47E	Stratojet	Med. bomb.	3	116'	107'	28'	.....	.....	.....	200,000	6 GE J47-GE @ 6,000 lb.t.
	B-52	Stratofortress	Heavy bomb.	6	185'	156'	48'	.....	.....	.....	350,000	8 P&W J57 @ 10,000 lb.t.
	KC-97G	Stratofreighter	Tanker-trans.	5	141' 3"	110' 4"	38' 3"	1,768	78,884	153,000	350,000	4 P&W R4360-59B @ 3,500 l
	KC-135	Stratotanker	Tanker-trans.	4	130' 10"	136' 3"	38' 5"	.....	.....	.....	.....	4 P&W J57 @ 10,000 lb. t.
Cessna Aircraft Co. *Wichita, Kan.*	T-37	.....	Trainer	2	33' 10"	29' 3"	9' 2"	183' 11"	.....	5,600	.....	2 Con. J69 @ 920 lb.t.
	TL-19D	.....	Inst. Trainer	2	36' 0"	28' 9"	7' 6"	175'	1,604	2,400	.....	1 Con. O-470-L @ 213 hp.
	OE-2	.....	Reconnaissance	2	.....	.....	.....	.....	1,835	2,650	.....	1 Con. O-470-2 @ 265 hp.
Convair Division, GDC *San Diego, Calif.*	B-36J	.....	Heavy bomb.	15	230'	162' 1"	46' 9"	4,772	.....	.....	400,000+	6 P&W R4360-53 @ 3,800 hp
	XB-58	Hustler	Bomber	..	55' 0"	95' 0"	31' 0"	.....	.....	.....	.....	4 GE J79-GE-1
	F-102A	.....	A-W interceptor	1	38' 2"	68' 3"	21' 3"	.....	.....	.....	.....	1 P&W J57-P-23 @ 10,000 lb
	TF-102A	.....	Trainer	2	38' 2"	63' 4"	21' 3"	.....	.....	.....	.....	1 P&W J57-P-23 @ 10,000 lb
	T-29C	Flying Classroom	Trainer	4	91' 9"	74' 8"	27' 3"	817	29,000	43,575	43,575	2 P&W R2800-99W @ 2,500
	C-131A	Samaritan	Air evac.	3	91' 9"	74' 8"	27' 3"	817	29,000	43,575	43,575	2 P&W R2800-99W @ 2,500
	C-131B	.....	Test bed	..	105' 4"	79' 2"	28' 2"	920	29,248	47,000	47,000	2 P&W R2800-99W @ 2,500
	YC-131C	.....	Exp. trans.	3	105' 4"	79' 2"	28' 2"	920	.....	.....	47,000	2 All. YT56-A3 @ 3,250 hp
	C-131D	.....	Transport	3	105' 4"	79' 2"	28' 2"	920	29,500	.....	48,500	2 P&W R2800-CB16 @ 2,400
	C-131E	.....	Utility trans.	3	105' 4"	79' 2"	28' 2"	920	31,735	49,100	49,100	2 P&W R2800-103W @ 2,500
	F-106A/B	.....	A-W Interceptor	1	38' 2"	.....	.....	.....	.....	.....	.....	1 P&W J75 @ 15,000 lb.t.
	R3Y-2	Tradewind	Transport	6	145' 9"	139' 6"	51' 8"	.....	.....	.....	160,000	4 All. T40-A-10 @ 5,500 hp.
	R4Y-1	.....	Transport	3	105' 4"	79' 2"	28' 2"	920	30,684	47,000	47,000	2 P&W R2800-52W @ 2,500
Douglas Aircraft Co., Inc. *Santa Monica, Calif.*	B-66B	Destroyer	Tac. bomber	3	72' 6"	75' 2"	23' 7"	780	42,086	78,000	83,000	2 All. J71-A-11 @ 10,000 lb.t.
	RB-66B	Destroyer	Night PR	3	72' 6"	75' 2"	23' 7"	780	42,797	70,000	83,000	2 All. J71-A-11 @ 10,000 lb.t.
	C-124C	Globemaster 2	Cargo trans.	5-9	174' 2"	130' 0"	48' 4"	2,506	101,165	185,000	194,500	4 P&W R4360-63A @ 3,800 l
	C-132	.....	Cargo trans.	..	.....	.....	.....	.....	.....	.....	.....	
	C-133A	.....	Cargo trans.	4-7	179' 8"	152' 8"	48' 3"	2,673	110,881	255,000	282,000	4 P&W T34-P-3 @ 5,700 esh
	A1D	Skyraider	Attack	1-3	50'	39'	15'	400	.....	19,000	25,000	1 Wr. R3350 @ 2,700 hp.
	A3D	Skywarrior	Attack	3	72' 6"	73' 6"	22' 9"	.....	.....	70,000	.....	2 P&W J57
	A4D	Skyhawk	Attack	1	27' 6"	39' 1"	15' 2"	.....	.....	15,000	.....	1 Wr. J65-W-4
	F4D	Skyray	Interceptor	1	33' 6"	44' 4"	13' 0"	557	.....	26,000	.....	1 P&W J57
	F5D	Skylancer	A-W Interceptor	1	.....	.....	.....	.....	.....	.....	.....	1 P&W J57
Fairchild Aircraft Div. *Hagerstown, Md.*	C-119G	Flying Boxcar	Cargo trans.	5	109' 3"	86' 6"	26' 3"	1,447	39,920	64,000	74,400	2 Wr. R3350-85W @ 3,500 hp
	C-123B	Provider	Assault trans.	2	110'	76' 3"	34' 1"	1,223	31,380	56,500	60,000	2 P&W R2800-99W @ 2,500
Grumman Aircraft Eng'g. Corp. *Bethpage, L. I., N. Y.*	F9F-8	Cougar	Fighter	1	34' 6"	41' 7"	12' 3"	.....	.....	.....	.....	1 P&W J48-P-8 @ 7,200 lb.t.
	F11F-1	Tiger	Fighter	1	31' 8"	46' 10"	12' 9"	.....	.....	.....	.....	1 Wr. J65-W-6
	S2F-1	Tracker	Anti-sub.	4	69' 8"	42' 3"	16' 3"	.....	.....	.....	.....	2 Wr. R1820-82 @ 1,525 hp.
	TF-1	Trader	Cargo/trans.	2	69' 8"	42' 0"	16' 3"	.....	.....	.....	.....	2 Wr. R1820-82 @ 1,525 hp.
	WF-1	.....	Early warning	..	69' 8"	.....	.....	.....	.....	.....	.....	2 Wr. R1820-82 @ 1,525 hp.
	SA-16A	Albatross	Rescue	6	80'	62' 4"	24' 5"	.....	24,000	.....	34,000	2 Wr. R1820-76A @ 1,425 hp
	SA-16B	Albatross	Rescue	6	96' 8"	62' 4"	29' 11"	.....	25,000	.....	35,000	2 Wr. R1820
Lockheed Aircraft Corp. *Burbank, Calif.*	F-104A	Starfighter	Fighter	1	22'	54' 0"	13' 6"	.....	.....	.....	.....	1 GE J79-GE-3
	T-33A	.....	Trainer	2	38' 11"	37' 8"	11' 8"	238	8,400	11,700	15,000	1 All. J33-A-35 @ 5,200 lb.t.
	WV-2	Super Constellation	Early warning	32	123' 5"	116' 2"	27' 0"	1,654	.....	.....	.....	4 Wr. R3350 @ 3,250 hp.
	C-130A	Hercules	Transport	4	132' 7"	98' 2"	38' 4"	1,746	.....	108,000	124,000	4 All. T56-A-1 @ 3,750 hp.
	T2V-1	SeaStar	Trainer	2	42' 0"	38' 0"	13' 0"	.....	.....	.....	16,000	1 All. J33
	P2V-7	Neptune	Anti-sub.	..	103'	91' 5"	29' 4"	1,000	47,450	75,500	.....	2 Wr. R3350-32W @ 3,500 hp
	R7V-2	Super Constellation	Transport	4-18	117'	116' 2"	24' 6"	1,615	72,219	150,000	199,800	2 We. J34 @ 3,400 lb.t. 4 P&W T34-P-12A @ 5,500 h
Glenn L. Martin Co. *Baltimore 3, Md.*	B-57B	.....	Tac. bomber	2	64'	65' 6"	16' 0"	.....	.....	.....	50,000	2 Wr. J65-W-8 @ 7,200 lb.t.
	P5M-2	Marlin	Anti-sub.	7	118' 0"	99'	33'	1,406	46,933	.....	73,055	2 Wr. R3350-32W @ 3,400 hp
	XP6M-1	SeaMaster	Mine-laying	5	100'	134'	31'	1,000	.....	.....	.....	4 All. J71 @ 10,000 lb.t.
McDonnell Aircraft Corp. *St. Louis, Mo.*	F-101A	Voodoo	Fighter	1	37' 8"	67' 5"	18' 0"	.....	.....	.....	.....	2 P&W J57-P-13 @ 10,000 lb
	F3H-2N	Demon	Fighter	1	35' 4"	58' 11"	14' 7"	.....	.....	.....	.....	1 All. J71-A-2 @ 9,500 lb.t.
North American Aviation, Inc. *Los Angeles, Calif.*	F-86D	Sabre	Fighter	1	37' 1"	41' 8"	15'	.....	.....	.....	18,000	1 GE J47-GE-17 @ 5,200 lb. t.
	F-86F	Sabre	Fighter	1	37' 1"	37' 5"	14' 7"	.....	.....	.....	17,000	1 GE J47-GE-27 @ 5,800 lb.t.
	F-86H	Sabre	Fighter-bomb.	1	37' 1"	38' 8"	15'	.....	.....	.....	.....	1 G . J73-GE-3
	F-86K	Sabre	Fighter	1	37' 1"	42' 6"	15'	.....	.....	18,800	20,347	1 GE J47-GE-33 @ 5,000 lb.t.
	F-100C	Super Sabre	Fighter	1	38'	47'	15'	.....	.....	.....	.....	1 P&W J57-P-7 @ 10,000 lb.t.
	F-100D	Super Sabre	Fighter-bomb.	1	38'	47'	16'	.....	.....	.....	.....	1 P&W J57 @ 10,000 + lb.t.
	F-100F	Super Sabre	Fighter-bomb.	2	39'	50'	16'	.....	.....	.....	.....	1 P&W J57-P-21 10,000 + lb.
	T2J	.....	Trainer	2	36'	38'	.....	.....	.....	.....	.....	1 We. J34 @ 3,400 lb.t.
	F-107	.....	Fighter	..	.....	.....	.....	.....	.....	.....	.....	
	T-28C	Trojan	Trainer	2	40' 7"	34' 4"	12' 7"	.....	.....	.....	8,247	1 Wr. R1820 @ 1,425 hp.
	FJ-3	Fury	Fighter	1	37' 1"	37' 7"	13' 8"	.....	.....	.....	18,000	1 Wr. J65 @ 7,200 lb.t.
	FJ-4	Fury	Fighter	1	39' 1"	37' 6"	13' 8"	.....	.....	.....	19,000	1 Wr. J65-W-4 @ 7,800 lb.t.
Northrop Aircraft, Inc. *Hawthorne, Calif.*	T-38	.....	Trainer	2	.....	.....	.....	.....	.....	.....	.....	
	F-89D	Scorpion	A-W inter.	2	59' 8"	53' 9"	17' 6"	600+	.....	.....	40,000+	2 All. J35-A-35
	F-89H	Scorpion	A-W inter.	2	59' 8"	53' 10"	17' 6"	600+	.....	.....	.....	2 All. J35-A-35
	F-89J	Scorpion	A-W inter.	2	59'	53'	17' 6"	.....	.....	.....	.....	
Republic Aviation Corp. *Farmingdale, L. I., N. Y.*	F-84F	Thunderstreak	Fighter-bomb.	1	33' 6"	43' 4"	14' 4"	.....	.....	.....	25,000	1 Wr. J65-W-3 @ 7,200 lb.t.
	RF-84F	Thunderflash	Recce M.-Plr	1	33' 6"	47' 6"	15'	.....	.....	.....	.....	1 Wr. J65-W-3 @ 7,200 lb.t.
	XF-84H	.....	Research	1	33' 6"	51' 5"	15' 4"	.....	.....	.....	.....	1 All. T40-A-1 @ 5,850 esh
	F-103	.....	Interceptor	1	.....	.....	.....	.....	.....	.....	.....	1 Wr. J67 @ 15,000 lb.t.
	F-105A	.....	Fighter-bomb.	1	.....	.....	.....	.....	.....	.....	.....	1 P&W J57 @ 10,000 lb.t.
Stroukoff Aircraft Corp. *West Trenton, N. J.*	XC-123D	.....	Assault trans.	2	110' 0"	76' 3"	34' 1"	1,235	.....	55,000	.....	2 P&W R2800-99W @ 2,500 l
	YC-123E	.....	Assault trans.	2	110' 0"	77' 2"	32' 10"	1,223	34,000	55,000	.....	2 P&W R2800-99W @ 2,500 l
	YC-134	.....	Assault trans.	2	110' 0"	82' 1"	34' 9"	1,235	37,380	60,000	.....	2 P&W R3350-89A @ 3,500 h
Temco Aircraft Corp. *Dallas, Tex.*	TT-1	.....	Primary Trainer	2	21' 10"	30' 1"	10' 10"	150	3,139	4,400	4,400	1 Con. J69-T-9 @ 920 lb t.
Chance Vought Aircraft, Inc. *Dallas, Tex.*	F8U-1	Crusader	Day fighter	1	.....	.....	.....	.....	.....	.....	.....	1 P&W J57-P-4

POWERPLANT		PERFORMANCE					ARMAMENT	CHRONOLOGY				REMARKS
Number, manufacturer, model and max. rating	Normal fuel cap., gal.	Maximum speed, mph.	Initial rate of climb, fpm.	Stall speed, dirty, mph.	Service ceiling, ft.	Combat radius, mi.	Number, type and designation	First flight of prototype	First production contract	First deliveries to service	First flight first prod.	
480-D1A @ 275 hp.	156	206	.....	...	.....	.....	None	.....	.....	June '55	.....	Civilian Aero 560A
480-A1A6 @ 340 hp.	223	260	.....	...	.....	.....	None	.....	.....	Mar. '56	.....	Civilian Aero 680S
0-1 @ 295 hp.	180	214	1,620	80	24,800	.....	None	.....	.....	.....	.....	
480-A1A6 @ 340 hp.	134	240	1,450	67	20,000	.....	None	.....	.....	.....	.....	
70-13 @ 225 hp.	50	189	1,230	54	20,000	.....	2 x .30-cal. mg. 6 rockets	Dec. '48	.....	Aug. '50	Oct. '53	T-34B is Navy version
T-9 @ 920 lb. t.	180	295	1,440	65	25,000	.....	.....	Dec. '55	.....	.....	.....	
E @ 6,000 lb.t.	.....	600+	.....	...	40,000+	1,500+	2 x 20-mm. cannon; 20,000 lb. of bombs; GAM-63 Rascal	Dec. '47	Sept. '48	Oct. '51	June '50	Also reconnaissance version RB-47E; 34 in. longer
@ 10,000 lb.t.	.....	600+	.....	...	50,000+	.....	.....	Apr. '52	Mar. '51	June '55	Aug. '54	
60-59B @ 3,500 hp.	9,190	375	1,200	107	28,000	.....	None	Nov. '44	July '45	1947	Mar. '47	
@ 10,000 lb. t.	.....	600+	.....	...	35,000+	.....	None	.....	Sept. '54	.....	Aug. '56	Development based on 707 prototype
@ 920 lb.t.	317	350	...	82	33,000	.....	.....	Oct. '54	July '54	Sept. '55	Sept. '55	
0-L @ 213 hp.	40	140	1,100	52	18,500	.....	.....	.....	.....	.....	.....	
0-2 @ 265 hp.	52	180	1,570	48	22,350	575	Bombs	Sept. '54	.....	.....	.....	
60-53 @ 3,800 hp.	30,000	435+	.....	...	45,000	5,000	16 x 20-mm. cannon	Aug. '46	Aug. '47	Aug. '47	Aug. '47	
E-1	.....	1,000	.....	...	.....	.....	.....	Nov. '56	.....	.....	.....	Delta wing podded engines
P-23 @ 10,000 lb.t.	.....	M>1	.....	...	50,000+	.....	GAR-98 Falcon missiles	Oct. '53	.....	.....	.....	
P-23 @ 10,000 lb.t.	.....	.....	.....	...	50,000+	.....	.....	.....	Apr. '54	Nov. '55	Oct. '55	
00-99W @ 2,500 hp.	1,550	300	1,370	92	24,000	.....	None	Sept. '49	.....	.....	.....	T-29D is equivalent for bombardier-training
00-99W @ 2,500 hp.	1,550	312	1,410	96	24,500	.....	None	Mar. '54	1952	1954	1954	
00-99W @ 2,500 hp.	1,730	295	1,410	...	24,500	.....	None	Dec. '54	.....	.....	.....	Avionic test bed; 340 airframe
A3 @ 3,250 hp	1,730	366	2,380	...	36,300	.....	None	May '54	.....	1954	.....	
00-CB16 @ 2,400 hp.	1,730	314	1,220	88	.....	.....	None	June '54	.....	.....	June '54	Equivalent to comm. 340 Convair-Liner
00-103W @ 2,500 hp.	1,730	310	.....	85	.....	.....	None	Dec. '55	.....	July '50	Dec. '55	
@ 15,000 lb.t.	.....	.....	.....	...	.....	.....	Douglas Ding-Dong missile; nuclear warhead	.....	.....	.....	.....	
-10 @ 5,500 hp.	.....	350+	.....	...	.....	.....	None	Apr. '50	.....	.....	Oct. '54	R3Y-1 is 142' 6" long
00-52W @ 2,500 hp.	1,730	.....	.....	...	.....	.....						
-11 @ 10,000 lb.t.	4,650	.....	.....	...	.....	.....	2 x 20-mm. cannon	June '54	Aug. '53	June '55	Jan. '55	USAF version of original A3D design for Navy
-11 @ 10,000 lb.t.	4,490	.....	.....	...	.....	.....	2 x 20-mm. cannon	June '54	May '53	Apr. '55	Mar. '55	RB-66C under development
60-63A @ 3,800 hp.	11,058	304	760	106	22,100	1,000	None	.....	Sept. '50	Apr. '53	Feb. '53	
	.....	.....	.....	...	.....	.....	.....	.....	.....	.....	.....	Swept wing turboprop
-P-3 @ 5,700 eshp.	16,000	.....	.....	...	.....	.....	None	.....	1954	1956	Apr. '58	
) @ 2,700 hp.	.....	.....	.....	...	.....	.....	4 x 20-mm. cannon	.....	.....	.....	.....	
	.....	650+	.....	...	45,000+	.....	2 x 20-mm. cannon	Oct. '52	.....	.....	.....	
7-4	.....	700+	.....	...	.....	.....	.....	1954	.....	.....	.....	Smallest A-bomb carrier
	.....	M>1	.....	...	40,000+	.....	.....	Jan. '51	.....	.....	.....	Holds 100 km. closed-circuit record: 728.11 mph.
	.....	M>1	.....	...	.....	.....	.....	Apr. '56	.....	.....	.....	
9-85W @ 3,500 hp.	2,624	293	800	84	30,000	1,110	None	Nov. '52	Jan. '52	May '53	Dec. '52	
00-99W @ 2,500 hp.	1,462	200	875	75	29,000	1,460	None	.....	Nov. '53	Oct. '54	Aug. '54	Original design was Chase Aircraft's
P-8 @ 7,200 lb.t.	.....	.....	.....	...	.....	.....	4 x 20-mm. cannon	Jan. '54	.....	.....	.....	Trainer version 34" longer has 2 seats, 2 cannon
-6	.....	.....	.....	...	.....	.....	Air-to-air missiles; 4 cannon	July '54	.....	.....	.....	F11F-1F has GE J-79-w1 has reached 72,000 ft.
9-92 @ 1,525 hp.	.....	.....	.....	...	.....	.....	Sonobuoys	Dec. '52	.....	.....	.....	Combines hunter-killer functions
9-92 @ 1,525 hp.	.....	.....	.....	...	.....	.....	None	Jan. '55	.....	.....	.....	
9-82 @ 1,525 hp.	.....	.....	.....	...	.....	.....	.....	.....	.....	.....	.....	
9-76A @ 1,425 hp.	1,275	275	1,400	...	.....	.....	None	.....	.....	.....	.....	Also Navy UF-1 & Coast Guard UF-1G
)	.....	.....	.....	...	.....	.....	None	.....	.....	.....	.....	
E-3	.....	M>1	.....	...	60,000	.....	.....	Feb. '54	Oct. '54	.....	Feb. '56	Straightwing, very thin section
-35 @ 5,200 lb.t.	813	600	4,680	100	46,000+	480	2 x .50-cal. mg.	Mar. '48	Oct. '47	Aug. '48	Sept. '48	Also Navy TV-2, USAF RT-33
9 @ 3,250 hp.	7,750	300	.....	...	.....	.....	None	.....	.....	.....	.....	WV-2 is Navy equivalent
-1 @ 3,750 hp.	.....	.....	.....	...	.....	.....	None	Aug. '54	Sept. '52	.....	Apr. '55	Production at Lockheed, Marietta, Ga.
	.....	600	.....	...	.....	.....	.....	Dec. '54	.....	.....	Jan. '56	Navy development
-32W @ 3,500 hp. +	.....	.....	.....	...	.....	.....	6 x 20-mm. cannon	May '45	.....	Apr. '54	.....	Holds non-stop record (11,236 mi.)
3,400 lb.t.	.....	360	.....	...	22,000	.....	.....	.....	.....	.....	.....	
P-12A @ 5,500 hp.	8,770	450	3,360	104	38,500	.....	None	Sept. '54	.....	.....	.....	YC-121F has P&W T34-P-6 @ 5,700 eshp.
-5 @ 7,200 lb.t.	.....	600+	.....	...	45,000+	.....	6 x .50-cal. mg. or 4 x 20 mm. cannon, bombs, and rockets	.....	.....	Aug. '53	.....	B-57A was test vehicle; RB-57 is recce; B-57C is transition trainer. B-57D and E are developments.
-32W @ 3,400 hp.	2,815	250	.....	...	.....	.....	.....	Aug. '53	.....	June '54	.....	
10,000 lb.t.	.....	600+	.....	...	40,000+	.....	Mines	.....	.....	.....	1955	Camera pod mounts in bomb bay in PR version
P-13 @ 10,000 lb.t.	.....	.....	.....	...	.....	.....	Atomic stores, GAR-98 missiles	Sept. '54	Sept. '52	.....	Sept. '54	Also RF-101A and F-101B 2-place
2 @ 9,500 lb.t	.....	.....	.....	...	.....	.....	4 x 20-mm. cannon; rockets	.....	.....	.....	Apr. '55	
-17 @ 5,200 lb. t.	.....	650+	.....	...	45,000+	500	24 x 2.75-in. rockets	Dec. '49	.....	Mar. '52	.....	
-27 @ 5,800 lb.t.	.....	650+	.....	...	45,000+	500+	6 x .50-cal. mg.; 16 x 5-in. HVAR	.....	.....	.....	.....	
-3	.....	630+	.....	...	45,000+	1,150	4 x 20-mm. M39 cannon	Apr. '53	.....	.....	Sept. '53	
-33 @ 5,600 lb.t.	.....	650+	.....	...	45,000+	500+	4 x 20-mm. M39 cannon	July '54	.....	.....	.....	
P-7 @ 10,000 lb.t.	.....	822	.....	...	50,000+	500+	20-mm. cannon	May '53	Mid-1953	Sept. '54	.....	
@ 10,000 + lb.t.	.....	822	.....	...	50,000+	500+	4 x 20-mm. M39 cannon	Jan. '56	.....	Mid-1956	.....	
P-21 10,000 + lb.t.	.....	822	.....	...	50,000+	500+	2 x 20-mm. M39 cannon	Aug. '56	.....	.....	.....	
3,400 lb.t.	.....	460	.....	75	40,000+	.....	.....	.....	.....	.....	.....	
	.....	.....	.....	...	.....	.....	.....	.....	.....	.....	.....	Redesignated from F-100B
@ 1,425 hp.	.....	346	3,830	...	37,000	430+	.50-cal. mg.; 2.25-in. rockets	Sept. '55	Sept. '54	.....	.....	
7,200 lb.t.	.....	.....	.....	...	45,000	500+	4 x 20-mm. cannon	July '53	.....	.....	.....	
-4 @ 7,800 lb.t.	.....	600+	.....	...	45,000+	.....	4 x 20-mm. cannon	Oct. '54	.....	.....	.....	
5	.....	M>1	.....	...	.....	.....	.....	.....	.....	.....	.....	Convertible to fighter
5	.....	600+	.....	...	52,000+	.....	104 x 2.75-in. rockets	Oct. '51	Apr. '51	Apr. '53	Jan. '53	Armament in wingtip pods
5	.....	.....	.....	...	.....	.....	42 x 2.75-in. rockets, 6 x GAR-98	.....	.....	.....	.....	
	.....	600+	.....	...	.....	.....	.....	.....	.....	.....	.....	
3 @ 7,200 lb.t.	.....	650+	.....	...	45,000+	1,000	6 x .50-cal. mg.; 24 x 5" rockets	June '50	Apr. '51	Mar. '53	Nov. '52	
3 @ 7,200 lb.t.	.....	650+	.....	...	45,000+	1,000	4 x .50-cal. mg.	Feb. '52	Apr. '51	May '54	Sept. '53	
1 @ 5,850 eshp.	.....	.....	.....	...	40,000+	.....	.....	July '55	.....	.....	.....	
15,000 lb.t.	.....	.....	.....	...	.....	.....	.....	.....	.....	.....	.....	
@ 10,000 lb.t.	.....	M>1	.....	...	.....	.....	.....	Oct. '55	.....	.....	.....	
0-99W @ 2,500 hp.	1,514	290	.....	...	.....	.....	None	Nov. '54	Apr. '55	.....	.....	Boundary-layer control tests
0-99W @ 2,500 hp.	1,514	290	.....	...	.....	.....	None	July '55	Apr. '55	.....	.....	Pantolense transport
0-99A @ 3,500 hp.	2,632	308	.....	...	.....	.....	None	Dec. '56	.....	.....	.....	Boundary-layer control pantolense transport
9 @ 920 lb.t.	124	285	1,400	63	30,000	276	None	Mar. '56	June '56	.....	.....	
-4	.....	1,020	.....	...	.....	.....	Rockets, 4 x 20mm cannon	Mar. '55	.....	.....	Sept. '55	

DIMENSIONS			WEIGHTS			POWERPLANT		PERFORMANCE					ARMAMENT	CHRONOLOGY				REMARKS
Overall length, ft.	Overall height, ft.-in.	Gross wing area, sq. ft.	Weight empty, lb.	Normal gross wt., lb.	Maximum gross wt., lb.	Number, manufacturer, model and max. rating	Normal fuel cap., gal.	Maximum speed, mph	Initial rate of climb, fpm	Stall speed, dirty, mph	Service ceiling, ft.	Combat radius, mi.	Number, type and designation	First flight of prototype	Firm production contract	First delivery to service	First flight first prod.	
33' 5"	14' 9"	242	4,145	6,000	.....	2 Lyc. GO-480-D1A 6s 275 hp.	156	206	.....	...	.....	.....	None	.....	.....	June '55	.....	Civilian Aero 560A
33' 5"	14' 9"	242	4,330	7,000	.....	2 Lyc. GSO-480-A1A6 6s 340 hp.	223	260	.....	...	.....	.....	None	.....	.....	Mar. '56	.....	Civilian Aero 680S
31' 6"	11' 4"	227	4,881	7,000	.....	2 Lyc. O-480-1 6s 295 hp	180	214	1,620	80	24,800	.....	None	.....	.....	.....	.....	
31' 6"	11' 4"	227	4,615	6,300	.....	2 Lyc. GSO-480-A1A6 6s 340 hp.	134	240	1,450	67	20,000	.....	None	.....	.....	.....	.....	
33' 11"	9' 2"	178	2,170	2,900	.....	1 Con. O-470-13 6s 225 hp.	50	189	1,230	54	20,000	.....	2 x .30-cal. mg. 6 rockets	Dec. '48	.....	Aug. '50	Oct. '53	T-34B is Navy version
30' 0"	9' 9"	178	3,034	4,360	.....	1 Con. J69-T-9 6s 920 lb. t.	180	295	1,440	65	25,000	.....	.....	Dec. '55	.....	.....	.....	
93'	28'	.....	.....	.....	200,000	6 GE J47-GE 6s 6,000 lb.t.	.....	600+	.....	...	40,000+	1,500+	2 x 20-mm. cannon; 20,000 lb. of bombs; GAM-63 Rascal	Dec. '47	Sept. '48	Oct. '51	June '50	Also reconnaissance version RB-47E; 34 in. longer
116'	48'	.....	.....	350,000	.....	8 P&W J57 6s 10,000 lb.t.	.....	600+	.....	...	50,000+	.....	.....	Apr. '52	Mar. '51	June '55	Aug. '54	
110' 4"	38' 3"	1,768	78,884	153,000	350,000	4 P&W R4360-59B 6s 3,800 hp.	9,190	375	1,200	107	28,000	.....	None	Nov. '44	July '45	1947	Mar. '47	
130' 3"	38' 5"					4 P&W J57 6s 10,000 lb. t.	.....	600+	.....	...	35,000+	.....	None	.....	Sept. '54	.....	Aug. '56	Development based on 707 prototype
29' 3"	9' 2"	183' 11"		5,600	.....	2 Con. J69 6s 920 lb.t.	317	360	.....	82	33,000	.....	.....	Oct. '54	July '54	Sept. '55	Sept. '55	
23' 9"	7' 6"	175'	1,604	2,400	.....	1 Con. O-470-L 6s 213 hp.	40	140	1,100	52	18,500	.....	.....	.....	.....	.....	.....	
			1,835	2,650	.....	1 Con. O-470-2 6s 265 hp.	52	180	1,570	48	22,350	575	Bombs	Sept. '54	.....	.....	.....	
42' 1"	46' 9"	4,772	.....	.....	400,000+	6 P&W R4360-53 6s 3,800 hp.	30,000	435+	.....	...	45,000	5,000	16 x 20-mm. cannon	Aug. '46	Aug. '47	Aug. '47	Aug. '47	
130' 0"	31' 0"	.....	.....	.....	.....	4 GE J79-GE-1	.....	1,000	.....	...	.....	.....	.....	Nov. '56	.....	.....	.....	Delta wing podded engines
130' 3"	31' 3"	.....	.....	.....	.....	1 P&W J57-P-23 6s 10,000 lb.t.	.....	M>1	.....	...	50,000+	.....	GAR-98 Falcon missiles	Oct. '53	.....	.....	.....	
130' 4"	31' 3"	.....	.....	.....	.....	1 P&W J57-P-23 6s 10,000 lb.t.	.....	.....	.....	...	50,000+	.....	.....	.....	Apr. '54	Nov. '55	Oct. '55	
73' 8"	27' 3"	817	29,000	43,575	43,575	2 P&W R2800-99W 6s 2,500 hp.	1,550	300	1,370	92	24,000	.....	None	Sept. '49	.....	.....	.....	T-29D is equivalent for bombardier-training
73' 8"	27' 3"	817	29,000	43,575	43,575	2 P&W R2800-99W 6s 2,500 hp.	1,550	312	1,410	98	24,500	.....	None	Mar. '54	1952	1954	1954	
79' 2"	28' 2"	920	29,248	47,000	47,000	2 P&W R2800-99W 6s 2,500 hp.	1,730	295	1,410	...	24,500	.....	None	Dec. '54	.....	.....	.....	Avionic test bed; 340 airframe
79' 2"	28' 2"	920	.....	.....	47,000	2 All YT56-A3 6s 3,250 hp.	1,730	366	2,380	...	36,300	.....	None	May '54	.....	1954	.....	
79' 2"	28' 2"	920	29,600	.....	46,500	2 P&W R2800-CB16 6s 2,400 hp.	1,730	314	1,220	86	.....	.....	None	June '54	.....	.....	June '54	Equivalent to comm. 340 Convair-Liner
79' 2"	28' 2"	920	31,735	49,100	49,100	2 P&W R2800-103W 6s 2,500 hp.	1,730	310	.....	85	.....	.....	None	Dec. '55	.....	July '60	Dec. '55	
.....	.....	.....	.....	.....	.....	1 P&W J75 6s 15,000 lb.t.	.....	.....	.....	...	.....	.....	Douglas Ding-Dong missile; nuclear warhead	.....	.....	.....	.....	
109' 8"	51' 5"				160,000	4 All T40-A-10 6s 5,500 hp.	.....	350+	.....	...	.....	.....	None	Apr. '50	.....	.....	Oct. '54	R3Y-1 is 142' 6" long
79' 2"	28' 2"	920	30,684	47,000	47,000	2 P&W R2800-52W 6s 2,500 hp.	1,730	.....	.....	...	.....	.....	.....	.....	.....	.....	.....	
75' 2"	23' 7"	780	42,086	78,000	83,000	2 All J71-A-11 6s 10,000 lb.t.	4,650	.....	.....	...	.....	.....	2 x 20-mm. cannon	June '54	Aug. '53	June '55	Jan. '55	USAF version of original A3D design for Navy
75' 2"	23' 7"	780	42,797	70,000	83,000	2 All J71-A-11 6s 10,000 lb.t.	4,490	.....	.....	...	.....	.....	2 x 20-mm. cannon	June '54	May '53	Apr. '55	Mar. '55	RB-66C under development
130' 0"	48' 3"	2,500	101,165	185,000	194,500	4 P&W R4360-53A 6s 3,800 hp.	11,058	304	760	108	22,100	1,000	None	.....	Sept. '50	Apr. '53	Feb. '53	Swept wing turboprop
152' 8"	48' 3"	2,673	110,881	255,000	282,000	4 P&W T34-P-3 6s 5,700 eshp.	16,000	.....	.....	...	.....	.....	None	.....	1954	1956	Apr. '56	
39'	15'	400	.....	19,000	25,000	1 Wr R3350 6s 2,700 hp.	.....	.....	.....	...	.....	.....	4 x 20-mm. cannon	.....	.....	.....	.....	
73' 6"	22' 9"	.....	.....	70,000	.....	2 P&W J57	.....	650+	.....	...	45,000+	.....	2 x 20-mm. cannon	Oct. '52	.....	.....	.....	
39' 1"	15' 2"	.....	.....	15,000	.....	1 Wr J65-W-4	.....	700+	.....	...	.....	.....	.....	1954	.....	.....	.....	Smallest A-bomb carrier
44' 4"	13' 0"	557	.....	25,000	.....	1 P&W J57	.....	M>1	.....	...	40,000+	.....	.....	Jan. '51	.....	.....	.....	Holds 100 km. closed-circuit record: 728.11 mph.
						1 P&W J57	.....	M>1	.....	...	.....	.....	.....	Apr. '56	.....	.....	.....	
86' 6"	26' 3"	1,447	39,920	64,000	74,000	2 Wr R3350-85W 6s 3,500 hp.	2,624	293	800	84	30,000	1,110	None	Nov. '52	Jan. '52	May '53	Dec. '52	
76' 3"	34' 1"	1,223	31,380	56,500	60,000	2 P&W R2800-99W 6s 2,500 hp.	1,462	260	875	75	29,000	1,460	None	.....	Nov. '53	Oct. '54	Aug. '54	Original design was Chase Aircraft's
41' 7"	12' 3"	.....	.....	.....	.....	1 P&W J48-P-8 6s 7,200 lb.t.	.....	.....	.....	...	.....	.....	4 x 20-mm. cannon	Jan. '54	.....	.....	.....	Trainer version 34" longer has 2 seats, 2 cannon
46' 10"	12' 9"	.....	.....	.....	.....	1 Wr J65-W-6	.....	.....	.....	...	.....	.....	Air-to-air missiles; 4 cannon	July '54	.....	.....	.....	F11F-1F has GE J-79-w1 has reached 72,000 ft.
43' 3"	16' 3"	.....	.....	.....	.....	2 Wr R1820-82 6s 1,525 hp.	.....	.....	.....	...	.....	.....	Sonobuoys	Dec. '52	.....	.....	.....	Combines hunter-killer functions
42' 0"	16' 3"	.....	.....	.....	.....	2 Wr R1820-82 6s 1,525 hp.	.....	.....	.....	...	.....	.....	None	Jan. '55	.....	.....	.....	
						2 Wr R1820-82 6s 1,525 hp.	.....	.....	.....	...	.....	.....	.....	.....	.....	.....	.....	Also Navy UF-1 & Coast Guard UF-1G
92' 4"	24' 5"	.....	24,000	.....	34,000	2 Wr R1820-76A 6s 1,425 hp.	1,275	275	1,400	...	.....	.....	None	.....	.....	.....	.....	
92' 4"	26' 11"	.....	25,000	.....	35,000	2 Wr R1820	.....	.....	.....	...	.....	.....	None	.....	.....	.....	.....	
54' 0"	13' 6"	.....	.....	.....	.....	1 GE J79-GE-3	.....	M>1	.....	...	60,000	.....	.....	Feb. '54	Oct. '54	.....	Feb. '56	Straightwing, very thin section
37' 8"	11' 8"	238	8,400	11,700	15,000	1 All J33-A-35 6s 5,200 lb.t.	813	600	4,680	100	46,000+	480	2 x .50-cal. mg.	Mar. '48	Oct. '47	Aug. '48	Sept. '48	Also Navy TV-2, USAF RT-33
116' 2"	27' 6"	1,654	.....	.....	.....	4 Wr R3350 6s 3,250 hp.	7,750	300	.....	...	.....	.....	None	.....	.....	.....	.....	WV-2 is Navy equivalent
95' 2"	38' 6"	1,746	.....	108,000	124,000	4 All T56-A-1 6s 3,750 hp.	.....	.....	.....	...	.....	.....	None	Aug. '54	Sept. '52	.....	Apr. '55	Production at Lockheed, Marietta, Ga.
38' 0"	13' 0"	.....	.....	.....	16,000	1 All J33	.....	600	.....	...	.....	.....	.....	Dec. '54	.....	.....	Jan. '56	Navy development
91' 5"	29' 4"	1,000	47,450	75,500	.....	2 Wr R3350-32W 6s 3,500 hp. +	.....	.....	.....	...	.....	.....	6 x 20-mm. cannon	May '45	.....	Apr. '54	.....	Holds non-stop record (11,236 mi.)
						2 Wr J34 6s 3,400 lb.t.	.....	300	.....	...	22,000	.....	.....	.....	.....	.....	.....	
116' 2"	24' 6"	1,615	72,219	150,000	169,800	4 P&W T34-P-12A 6s 5,500 hp.	8,770	450	3,360	104	38,500	.....	None	Sept. '54	.....	.....	.....	YC-121F has P&W T34-P-6 6s 5,700 eshp.
65' 6"	16' 0"			.....	80,000	2 Wr J65-W-5 6s 7,200 lb.t.	.....	600+	.....	...	45,000+	.....	8 x .50-cal. mg. or 4 x 20 mm. cannon, bombs, and rockets	.....	.....	Aug. '53	.....	B-57A was test vehicle: RB-57 is recco; B-57C is transition trainer. B-57D and E are developments.
99'	33'	1,406	46,933	.....	73,055	2 Wr R3350-32W 6s 3,400 hp.	2,815	250	.....	...	.....	.....	.....	Aug. '53	.....	June '54	.....	
134'	31'	1,900	.....	.....	.....	4 All J71 6s 10,000 lb.t.	.....	600+	.....	...	40,000+	.....	Mines	.....	.....	.....	1955	Camera pod mounts in bomb bay in PR version
67' 5"	18' 0"			.....	.....	2 P&W J57-P-13 6s 10,000 lb.t.	.....	.....	.....	...	.....	.....	Atomic stores, GAR-98 missiles	Sept. '54	Sept. '52	.....	Sept. '54	Also RF-101A and F-101B 2-place
58' 11"	14' 7"			.....	.....	1 All J71-A-2 6s 9,500 lb.t.	.....	.....	.....	...	.....	.....	4 x 20-mm. cannon; rockets	.....	.....	.....	Apr. '55	
41' 8"	15'			.....	18,000	1 GE J47-GE-17 6s 5,200 lb.t.	.....	650+	.....	...	45,000+	500	24 x 2.75-in. rockets	Dec. '49	.....	Mar. '52	.....	
37' 5"	14' 7"			.....	17,000	1 GE J47-GE-27 6s 5,800 lb.t.	.....	650+	.....	...	45,000+	500+	6 x .50-cal. mg., 16 x 5-in. HVAR	.....	.....	.....	.....	
38' 8"	15'			.....	.....	1 GE J73-GE-3	.....	630+	.....	...	45,000+	1,150	4 x 20-mm. M39 cannon	Apr. '53	.....	.....	Sept. '53	
42' 4"	15'			18,500	20,347	1 GE J47-GE-33 6s 5,600 lb.t.	.....	650+	.....	...	45,000+	500+	4 x 20-mm. M39 cannon	July '54	.....	.....	.....	
42'	15'			.....	.....	1 P&W J57-P-7 6s 10,000 lb.t.	.....	822	.....	...	50,000+	500+	20-mm. cannon	May '53	Mid-1953	Sept. '54	.....	
42'	16'			.....	.....	1 P&W J57 6s 10,000 + lb.t.	.....	822	.....	...	50,000+	500+	4 x 20-mm. M39 cannon	Jan. '56	.....	Mid-1956	.....	
50'	16'			.....	.....	1 P&W J57-P-21 10,000 + lb.t.	.....	822	.....	...	50,000+	500+	2 x 20-mm. M39 cannon	Aug. '56	.....	.....	.....	
38'	.....			.....	.....	1 Wr J34 6s 3,400 lb.t.	.....	460	.....	75	40,000+	.....	.....	.....	.....	.....	.....	Redesignated from F-100B
34' 4"	12' 7"			.....	8,247	1 Wr R1820 6s 1,425 hp.	.....	346	3,830	...	37,000	430+	.50-cal. mg., 2.25-in. rockets	Sept. '55	Sept. '54	.....	.....	
37' 5"	13' 8"			.....	18,000	1 Wr J65 6s 7,200 lb.t.	.....	.....	.....	...	45,000	500+	4 x 20-mm. cannon	July '53	.....	.....	.....	
37' 4"	12' 8"			.....	19,000	1 Wr J65-W-4 6s 7,900 lb.t.	.....	600+	.....	...	45,000+	.....	4 x 20-mm. cannon	Oct. '54	.....	.....	.....	
								M>1	.....	...	.....	.....	.....					Convertible to fighter
53' 9"	17' 6"	600+	.....	.....	40,000+	2 All J35-A-35	.....	600+	.....	...	52,000+	.....	104 x 2.75-in. rockets	Oct. '51	Apr. '51	Apr. '53	Jan. '53	Armament in wingtip pods
53' 10"	17' 6"	600+	.....	.....	.....	2 All J35-A-35	.....	.....	.....	...	.....	.....	42 x 2.75-in. rockets, 6 x GAR-98	.....	.....	.....	.....	
53'	17' 6"			.....	.....		.....	600+	.....	...	.....	.....	.....	.....	.....	.....	.....	
43' 4"	14' 4"			.....	25,000	1 Wr J65-W-3 6s 7,200 lb.t.	.....	650+	.....	...	45,000+	1,000	6 x .50-cal. mg.; 24 x 5" rockets	June '50	Apr. '51	Mar. '53	Nov. '52	
42' 6"	15'			.....	.....	1 Wr J65-W-3 6s 7,200 lb.t.	.....	650+	.....	...	45,000+	1,000	4 x .50-cal. mg.	Feb. '52	Apr. '51	May '54	Sept. '53	
51' 5"	15' 4"			.....	.....	1 All T40-A-1 6s 5,850 eshp	.....	.....	.....	...	40,000+	.....	.....	July '55	.....	.....	.....	
				.....	.....	1 Wr J67 6s 15,000 lb.t.	.....	.....	.....	...	.....	.....	.....	.....	.....	.....	.....	
				.....	.....	1 P&W J57 6s 10,000 lb.t.	.....	M>1	.....	...	.....	.....	.....	Oct. '55	.....	.....	.....	
76' 3"	34' 1"	1,235		55,000	.....	2 P&W R2800-99W 6s 2,500 hp.	1,514	290	.....	...	.....	.....	None	Nov. '54	Apr. '55	.....	.....	Boundary-layer control tests
77' 2"	32' 10"	1,223	34,000	55,000	.....	2 P&W R2800-99W 6s 2,500 hp.	1,514	290	.....	...	.....	.....	None	July '55	Apr. '55	.....	.....	Pantobase transport
80' 4"	34' 9"	1,235	37,380	69,000	.....	2 P&W R3350-80A 6s 3,500 hp.	2,632	308	.....	...	.....	.....	None	Dec. '56	.....	.....	.....	Boundary-layer control-pantobase transport
30' 1"	10' 10"	150	3,139	4,400	4,400	1 Con J69-T-9 6s 920 lb.t.	124	285	1,400	63	30,000	276	None	Mar. '56	June '56	.....	.....	
.....	.....	.....	.....	.....	.....	1 P&W J57-P-4	.....	1,020	.....	...	.....	.....	Rockets, 4 x 20mm cannon	Mar. '53	.....	.....	Sept. '55	

USSR Military Aircraft

Basic Data				Physical Data			Powerplant	Performance		Armament	Remarks
	Designation	NATO Code name	No. of crew	Overall span, ft.	Overall length, ft.	Gross weight, lb.	Powerplant (No. x engine, rated power, each eng.)	Maximum speed, mph	Service ceiling, ft.		
FIRST-LINE AIRCRAFT											
STRATEGIC BOMBERS	.....	Bison	..	170	140	250,000	4 x Lulko tj.	610	57,000	.....	Comparable to B-52; 70 in service
	Tu-?	Bear	..	180	150	330,000	4 x 12,000 ehp. tp.	650	50,000	.....	Range about 8,000 mi.
	Tu-16	Badger	..	100	105	150,000	2 x Lulko tj.	600	50,000	.....	Comparable to Boeing B-47
TACTICAL BOMBERS	Il-28	Beagle	3	68	62	.....	2 x RD45 tj @ 5,000 lb.t.	600	45,000	2 x 23-mm. 2 x 12.7-mm.	Satellite production and use
	Il-?	Blowlamp	..	...	...	.....	2 x axial tj.	700	.....	.....	55° sweepback
	Tu-14	Bosun	3	70	65	50,000	2 x VK1 tj @ 5,000 lb.t.	500	.....	.....	Torpedo bomber
	.....	.....	3	...	...	.....	2 x axial tj.	.....	.....	4 x cannon turret & rockets	Close-support
FIGHTERS	MiG-21	Faceplate	1	33	50	.....	1 x axial tj.	1,200	.....	.....	Farmer development
	MiG-19	Farmer	1	...	...	27,000	2 x axial tj. @ 10,000 lb.t.	900	.....	2 x 23-mm.	Low-set slab tail; 3,000 in service
	Su-?	Fishbed A	1	...	...	.....	.....	.....	.....	.....	Delta; radome over inlet
	Su-?	Fishbed B	1	...	...	.....	.....	.....	.....	.....	Delta; no radome
	Su-?	Fishpot	1	...	...	.....	.....	.....	.....	.....	Delta
	Yak-25	Flashlight A	..	40	...	.....	2 x axial tj. @ 8,000 lb.t.	700	1,500	2 x 37-mm.	
	Yak-?	Flashlight B	..	40	55	30,000	2 x axial tj.	.....	.....	.....	Light bomber
	Yak-?	Flashlight C	2	40	55	30,000	2 x axial tj.	.....	.....	.....	Night fighter
	MiG-17	Fresco	1	33	37	15,000	1 x VK2JA tj. @ 6,850 lb.t.	M>1	51,000	2 x 23-mm. 1 x 37-mm.	MiG-15 development
	MiG-15	Fagot	1	33	36	11,268	1 x VK2 tj. @ 5,950 lb.t.	683	51,000	2 x 23-mm. 1 x 37-mm.	Satellite production and use; 15,000 minimum built
HELICOPTERS	Mi-1T	Hare	4	48.5'	...	4,938	1 x AI26B @ 575 hp.	105	.....	.....	Range: 400 mi.
	LAR-3	Hound	2	69'	...	12,015	1 x ASh62IR @ 1,000 hp.	130	11,800	None	Used at North Pole stations
	Yak-24	Horse	4	69'	75	35,000	2 x ASh 82B @ 1,430 hp.	.....	.....	None	Holds 2 FAI records
	Mi-3	.....	4	47'	39	5,180	.....	124	.....	.....	Mi-1T development
TRANSPORTS	An-2	Colt	2	54	35	11,000	1 x ASh62IR @ 1,000 hp.	137	27,890	None	Holds FAI altitude record
	An-4	Camp	...	...	...	77,160	2 x Ku tp. @ 5,100 ehp.	.....	.....	.....	
	An-10	.....	...	...	...	.....	4 x 4,000 ehp. tp.	450	.....	.....	70-passenger transport
	Il-12	Coach	2-5	104	70	38,000	2 x ASh82FNV @ 1,850 hp.	252	.....	None	Used by Polish, Czech & USSR airlines; 3,000 built
	Il-14	Crate	2-5	104	70	36,400	2 x ASh82T @ 1,900 hp.	200	1,990	None	Il-12 development/replacement; production at 30/month
	Il-14M	Crate	...	...	...	.....	.....	.....	.....	.....	24-passenger version
	Il-18	.....	...	...	...	.....	4 x tp.	.....	.....	.....	70-passenger transport
	Tu-104	Camel	3	114	121	120,152	2 x M-209 tj. @ 14,880 lb.t.	560	39,000	.....	ICAO range: 1,988 mi.
	Be-6	Madge		108		51,600	2 x ASh73 @ 2,000 hp.	260	3,045	.....	Patrol flying boat
SUPPORT AIRCRAFT											
BOMBERS	Il-10	Beast	2	45 5	40 0	.....	1 x AM42 @ 2,000 hp.	360	.....	2 x 7.62-mm. 1 x 12.7-mm.	Satellite use
	Il-26	Butcher	3	68	62	.....	2 x axial @ 5,000 lb.t.	570	45,000	2 x 23-mm. 1 x 20-mm.	Production predecessor of Il-28
	Tu-4	Bull	6-8	141	99	.....	4 x ASh82FNV @ 1,850 hp.	225	.....	.....	Russian copy of Boeing B-29
	Tu-?	Barge	...	185	145	210,000	4 x tp @ 4,500 hp.	380	.....	.....	Pre-production quantities; was turboprop testbed for Bear
	Tu-2	Bat	5	61 9	45 3	28,224	2 x ASh82FNV @ 1,850 hp.	360	36,000	2 x 20-mm. 2 x 12.7-mm.	Polish and Red Chinese service
FIGHTERS	La-7	Fin	1	32 3	28 5	7,482	1 x ASh82FNV @ 1,850 hp.	373	.....	.....	Second-line Red Chinese fighter
	La-9	Fritz	1	31 4	29 4	8,239	1 x ASh82FNV @ 1,850 hp.	394	.....	1 x 20-mm. 2 x 12.7-mm.	Russian trainer, Chinese fighter
	La-11	Fang	1	32 5	28 4	7,700	1 x ASh82FNV @ 1,850 hp.	420	.....	3 x 20-mm.	Last Russian piston-eng. fighter
	La-?	Fantail	1	37	40	.....	1 x RD45F @ 5,500 lb.t.	640	.....	2 x 23-mm.	Type 21; was called LA-17
	MiG-9	Fargo	1	34	33	14,000	2 x M004 @ 2,200 lb.t.	595	.....	1 x 23-mm. 2 x 20-mm.	First Red twin-jet; now trainer
	Yak-17	Feather	1	30	28	.....	1 x M004 @ 2,200 lb.t.	505	.....	2 x 20-mm.	Yak-15 development
	Yak-23	Flora	1	30	29	.....	1 x RD500 @ 3,500 lb.t.	610	45,000	.....	Polish, Bulgarian service
	Yak-3	.....	1	31	29	4,848	1 x VK105PF @ 1,210 hp.	343	.....	1 x 20-mm. 2 x 12.7-mm.	Satellite use
TRANSPORTS	Li-2	Cab	2	95	64	.....	2 x M62R @ 1,000 hp.	.....	.....	None	Russian-built Douglas C-47
	Tu-70	Cart	4	141	119	.....	4 x ASh82FNV @ 1,850 hp.	215	.....	None	Development of Tu-4 (Boeing B-29)
	Pe-8	.....	...	131	81	70,500	4 x M82III @ 1,700 hp.	240	23,000	None	Was bomber; now special duties
	Shche-2	.....	2	72	50	.....	2 x M11D @ 145 hp.	110	.....	None	Was Aeroflot feeder; now Polish
	Yak-16	Cork	2	66	49	14,000	2 x ASh21 @ 750 hp.	190	16,000	None	In service with Aeroflot
	Il-20	.....	3	68	62	.....	2 x RD45F @ 5,000 lb.t.	600	45,000	None	Il-28 "jet transport" conversion
TRAINERS	U-Il-28	Mascot	3	68	62	.....	2 x RD45F @ 5,000 lb.t.	600	45,000	.....	Il-28 development; satellite use
	U-MiG-15	Midget	2	33	36	12,000	1 x VK2 @ 5,950 lb.t	650	51,000	.....	Satellite use
	Pe-2	Buck	3	56	41	18,730	2 x VK105R @ 1,100 lb.t.	340	29,000	4 x 7.62-mm. 2 x 12.7-mm.	Satellite use
	Yak-11	Moose	2	31	28	4,999	1 x ASh21 @ 750 hp.	295	.....	.....	Holds FAI closed-circuit records
	U-Yak-17	Magnet	2	30	28	.....	1 x M004 @ 2,200 lb.t.	505	.....	2 x 20-mm.	Conversion trainer
	Yak-18	Max	2	35	26	2,360	1 x M11RF1 @ 160 hp.	160	16,400	None	Holds FAI speed records
	UT-2	Mink	2	34	23	2,075	1 x M11G @ 110 hp.	122	2,075	None	Satellite use; basic trainer
	Yak-12M	Creek	4	39	30	2,650	1 x AI14R @ 260 hp.	115	13,200	None	Air ambulance/communications
MISCELLANEOUS	Ka-10	.....	1	.....	.....	.....	1 x Poinela @ 50 hp.	.....	.....	None	Ultra-light co-axial 'copter
	Po-2	Mule	2	37	27	1,910	1 x M11 @ 110 hp.	96	13,200	None	Satellite use; freighter/agric
	GST	Mop	3-4	104	63	27,000	2 x M62R @ 1,000 hp.	190	25,000	.....	Russian-built Consol. PBY
	MDR-6	Mug	3	66	49	.....	2 x M62R @ 1,000 hp.	190	.....	.....	Flying boat

Abbreviations:

AM A. A. Mikulin
An O. K. Antonov
ASh A. D. Shvetsov
G Mikhail Gurevich
Il Sergei Ilyushin
La Semyon Lavochkin
M Motor (Old designation)
Mi Artem Mikoyan
Mil Mikhail Mil
Pe Vladimir Petlyakov
Po Nikolai Poliakarpov
Shche S. O. Shcherbakov
Su Pavel Sukhoi
tj Turbojet
tp Turboprop
Tu Andrei Tupolev
UT Uchebnii Trenirovochnii (trainer)
VK V. Klimov
Yak Aleksandr Yakovlev
† Rotor diameter

Other NATO code names given to Russian types include: Fred, Box and Bank (Bell P-63A, Douglas A-20 and North American B-25 respectively, sent to USSR during WW 2; Bob (Il-4, Bark (Il-2; Clam (Il-18 four-engine transport); Crib (Yak-6); Crow (Yak-14); Mark (Yak-7); Mote (MBR-2; Madge (seaplane similar to Martin Mariner); and the undisclosed Mole, Mare and Mist.

How Holley's Compressor Governors Help New Jets to Supersonic Speeds

"City-savers" Air Force men call them: the J-57-powered F-100, F-101, F-102 and Navy F8U, with level flight speeds faster than sound. And city-savers they could well be. Certainly their rapid approach to the fringe of Mach 2 heralds a new era in the progress of jet flight.

Sharing in the development of this new brood of supersonic fighters, Holley engineers, working closely with Pratt & Whitney Aircraft on the J-57 engine, designed the compressor bleed governor.

This new Holley compressor bleed governor is one more example of Holley's continuing leadership in the design, development and manufacture of superior engine control systems for both military and civilian use

Leader in the design, development, and manufacture of aviation fuel metering devices.

HOLLEY Carburetor Co.

11955 E. Nine Mile Road — Van Dyke, Michigan

A-24

Manufacturer	Designation	Type	No. compressor stages	No. turbine stages	No. combustors	Max. power @ S.L.	Specific fuel consumption at max. power, lb. hr. lb. or eshp.	Compression ratio at max. rpm.	Max. envelope diameter, in.	Max. envelope length, in.	Dry weight, less tailpipe, lb.	Remarks
Avco Manufacturing Corp.	XT53-L-1	ACS	5+1	2	1	825 shp.	0 71	5 9	23	48	460	To power Bell XH-40
Lycoming Division												In Kaman HOK
Stratford, Conn.	T55	ACS				1,800 shp.					660	
Continental Aviation and	J69-T-9	CFJ	1	1	1	920 lb. t.	1 13			50	364	In Cessna, Beech, Temco trainers
Engineering Corp.	J69-T-19A	CFJ	1	1	1	1,000 lb. t.	1 27			42	317	In Ryan Firebee
Detroit, Mich.	J69-T-23	ACJ	2	2	1	1,250 lb. t.						
	T51-T-1	CFP	1	2	1	280 eshp.	0 99		16	37	263	In Bell XH-13, Cessna XL-19C
	T51-T-3	CFP	1	2	1	425 eshp.	0 97			36	236	In Sikorsky XH-39
	215	ACS	2	2	1	590 eshp.			16	48	320	Output shaft rpm: 6,000
	324	ACJ	2	2	1	550 lb. t.	1 12				214	
	420	BP	2	2	1	790 lb. t.	0 55				315	Air pump in XC-123D,YC-134
Curtiss-Wright Corp.	J65-W-5	AFJ	13	2	1	7,200 lb. t.			37 5	109	2,750	In Martin B-57A and B, RB-57A
Wright Aeronautical Division	J65-W-6	AFJ	13	2	1	11,000 lb. t.			37 5	184	3,485	Afterburner version
Wood-Ridge, N. J.	J65-W-7	AFJ	13	2	1	7,800 lb. t.			37 5	115	2,795	In Republic XF-84F
	J65-W-14	AFJ	13	2	1	10,000 lb. t.			37 5	181	3,535	Afterburner
	J65-W-16-16A	AFJ	13	2	1	7,700 lb. t.			37 5	113	2,742	In NAA FJ-3, FJ-4
	J65-W-18	AFJ	13	2	1	10,000 lb. t.			37 5	181	2,485	In Grumman F11F-1
Fairchild Engine and Airplane Corp.	J44-R-3, -20B, -24, -26	ACJ	1	1	1	1,000 lb. t.	1 55	2 5	24	88	370	J44-R-3 auxiliary powerplant for inhabited aircraft; others, as J44-R-20B In Ryan Firebee drone, are for drones or missiles.
Fairchild Engine Division												
Deer Park, L. I., N. Y.	FT-101E	ACJ	1	1	1	1,000 lb. t.	1 55	2 5	24	96	370	Commercial variant.
General Electric Co.	J79	AFJ				12,000 lb. t.			40			Powers Lockheed F-104A, Convair XB-58, Grumman F11F-1F
Aircraft Gas Turbine Division												Nuclear power plant
Evendale, O.	T58	ACS		2+1	1	1,024 eshp.	0 69		16	59	325	High T/W ratio
	X84											Turbofan dev. by company.
	Nuclear eng.											
General Motors Corp.	J33-A-18A	CFJ	1	1	14	4,600 lb. t.	1 14	4 35	49	94	1,790	In C-V Regulus
Allison Division	J33-A-35	CFJ	1	1	14	4,600 lb. t.	1 14	4 35	52	106	1,820	In Lockheed T-33A, TV-2
Indianapolis, Ind.	J33-A-37	CFJ	1	1	14	4,600 lb. t.	1 14	4 35	52	156	1,520	In Martin TM-61A Matador
	J71-A-2	AFJ	16	3		10,000 lb. t.			43	285	4,017	In McDonnell F3H-2N Demon
	J71-A-11	AFJ	16	3		10,000 lb. t.			48	191	3,829	In Douglas RB-66, B-66
	T56-A-1	AFP	14	4	6	3,750 eshp.	0 54	9 25	40	145	1,645	In Lockheed C-130 Hercules
	501-D13	AFP	14	4	6	3,750 eshp.	0 54	9 25	36	145	1,750	To power Lockheed Electra
	501-D15	AFP				4,050 eshp.						
	550	AFP				5,500 eshp.						Split-compressor
United Aircraft Corp.	J48	CFJ	1	1	9	7,250 lb. t.	1 14	4	50	110	2,080	Commercial version is JT7H
Pratt & Whitney Aircraft Division	J52	AFJ				7,500 lb. t.						Split-compressor, civil version is JT9
E. Hartford, Conn.	J57	AFJ				10,000 lb. t.						Split-compressor.
	J75	AFJ				15,000 lb. t.						Split-compressor.
	T34	AFP	13	3	8	6,000 eshp.	0 63	6 7	34	157	2,564	
	T57	AFP				15,000 eshp.						Split-compressor.
	PT2G-3	AFP				6,000 eshp.	0 63	6 7	34	157	2,670	Commercial T34
	JT3C-4	AFJ				11,000 lb. t.						Commercial J57
	JT4A-3	AFJ				15,000 lb. t.						Commercial J75
	Nuclear eng.											
Westinghouse Electric Corp.	J34-WE-34	AFJ	11	2	1	3,250 lb. t.	1 06	4 1	24	120	1,233	Powers McDonnell F2H
Aviation Gas Turbine Division	J34-WE-36	AFJ	11	2	1	3,400 lb. t.	1 04	4 3	24	120	1,184	Powers Douglas F3D
Kansas City, Mo.												Auxiliary powerplant for Lockheed P2V
	J34-WE-46	AFJ										To power NAA T2J
	J46-WE-8	AFJ										Powers Chance-Vought F7U
	J54-WE-2	AFJ				6,700 lb. t.						High altitude engine for inhabited aircraft, or missiles
	XJ81-WE-3	AFJ				1,800 lb. t.						Expendable engine for missiles and drones. Americanized R-R Soar

Abbreviations:

- **ACJ** — Axial-centrifugal turbojet
- **ACS** — Axial-centrifugal shaft turbine
- **AFJ** — Axial-flow turbojet
- **AFP** — Axial-flow turboprop
- **ACS** — Axial-flow shaft turbine
- **CFJ** — Centrifugal flow turbojet
- **eshp** — Equiv. shaft horsepower
- **lb. t.** — Pounds thrust
- **BP** — By-pass

"Now, here, you see, it takes
all the running you can do,
to keep in the same place."

Charles Lutwidge Dodgson and the Red Queen

DR. DODGSON would be delighted with a parallel to the prophetic environment he devised for his Red Queen and Alice in his classic "Through The Looking Glass." The advanced-electronics industry is running as fast as possible to keep ahead of Tomorrow. But certain of America's advanced-electronics companies have achieved in their work a velocity that has borne them beyond hitherto unexplored frontiers. Litton Industries is among them.

LITTON INDUSTRIES BEVERLY HILLS, CALIFORNIA
Plants and Laboratories in California, Maryland, Indiana and New York

DIGITAL COMPUTERS & CONTROLS · RADAR & COUNTERMEASURES · INERTIAL GUIDANCE · SPACE SIMULATION RESEARCH
MICROWAVE POWER TUBES · AUTOMATIC DATA PROCESSING · SERVOMECHANISMS · PRECISION COMPONENTS & TRANSFORMERS

U. S. Commercial Transports

Aircraft General Data							Performance							Weights			Dimensions		
Manufacturer	Model	Name	No. of crew	No. of passengers	Cargo capacity, lb.	Number, designation of powerplants	Maximum speed, mph.	Best cruise speed, mph.	Landing speed, flaps and landing gear down, mph.	Engine-out en route climb, fpm.	CAA field length takeoff, ft.	CAA field length landing, ft.	Maximum still-air range, mi.	Weight empty, lb.	Maximum gross weight, lb.	Maximum landing weight, lb.	Wingspan, ft.	Overall length, ft.	Maximum height, ft.
Boeing Airplane Co.	707-120	Jet Stratoliner	3	80-130		4 P&W JT3-P		600							230,000+	165,000	130' 10"	134' 6"	38' 3"
	707-220	Jet Stratoliner	3	80-130		4 P&W JT-4		600							245,000+	175,000	130' 10"	134' 6"	38' 3"
	707-320	Intercontinental	4	124-146		4 P&W JT-4		600					4,000+		280,000+	190,000	141' 6"	146' 8"	38' 11"
	707-420	Intercontinental	4			4 Rolls-Royce Conway		600					4,000+		280,000+	190,000	141' 6"	146' 8"	38' 11"
Convair Division General Dynamics Corp.	340	Convair-Liner	3	44	5,400	2 P&W R2800-CB-16	314	284	86	1,220	4,675		1,260	29,486	47,000	46,500	105' 4"	79' 2"	28' 2"
	440	Metropolitan	4	44-52	5,400	2 P&W R2800-CB-17	310	289	85	150	5,000	4,010	2,752	31,305	49,100	47,650	105' 4"	79' 2"	28' 2"
	880		5	80-141	8,500	4 GE CJ805-1		615	138	650	6,220	5,930	3,900	80,900	178,500	123,500	120'	124' 2"	37' 4"
Douglas Aircraft Co., Inc.	DC-6A	Liftmaster	3-5	0	30,500	4 P&W R2800-CB-17	370	315	97	493	6,100	5,160	5,000	51,316	107,000	88,200	117' 6"	105' 6"	28' 8"
	DC-6B	(domestic version)	5	54	16,780	4 P&W R2800-CB-16	370	315	95	460	5,680	4,995	3,720	55,357	100,000	85,000	117' 6"	105' 6"	28' 8"
	DC-6B	(overwater version)	7[1]	99	11,930	4 P&W R2800-CB-17	370	315	97	493	6,100	5,160	5,000	58,340	107,000	88,200	117' 6"	105' 6"	28' 8"
	DC-7	(domestic version)	3	69-99	12,740	4 Wr 972TC18DA4	409	367		448	6,090	5,840	4,430	64,480	122,200	97,000	117' 6"	108' 11"	28' 7"
	DC-7B	(overwater version)	3	69-99	17,730	4 Wr 972TC18DA4	412	360		525	6,350	5,870	5,120	68,073	126,000	102,000	117' 6"	108' 11"	28' 7"
	DC-7C	Seven Seas	3-5	62-99	18,440	4 Wr 988TC18EA1	406	371		507	5,590	5,360	6,010	72,643	143,000	109,000	127' 6"	112' 3"	31' 10"
	DC-8	(domestic)		118-144	14,150	4 P&W JT-3C-4		565			9,440	6,680	6,040	119,726	250,000	189,000	139' 9"	150' 6"	42' 4"
	DC-8	(domestic)		118-144	14,150	4 P&W JT-3C-6		565			9,200	6,680	5,800	118,037	258,700	189,000	139' 9"	150' 6"	42' 4"
	DC-8	(intercontinental)		132-144	14,150	4 P&W JT-4A-3		595			8,760	6,600	4,470	128,862	287,500	190,500	139' 9"	150' 6"	42' 4"
	DC-8	(intercontinental)		132-144	14,150	4 Rolls-Royce Conway		582			9,000	6,680	6,890	123,726	287,500	190,500	139' 9"	148' 10"	42' 4"
Lockheed Aircraft Corp.	1049G	Super Constellation	5-11	47-99		4 Wr 972TC18DA3	370	335	101	630	6,300	5,250	5,580	73,016	137,500	113,000	123' 5"	116' 2"	24' 9"
	1049H	Super Constellation	5-11		40,000	4 Wr 972TC18DA3	370	335	101	630	6,300	5,250	5,580	70,000	137,500	113,000	123' 5"	116' 2"	24' 9"
	1649A	Super Constellation	5-11	47-99		4 Wr 988TC18EA2	377	350	101	550	6,520	6,050	6,400	85,553	156,000	123,000	150'	116' 2"	24' 9"
	188	Electra	3-6	66-91		4 All 501-D13	448	407	101				2,740	86,000	113,000	95,650	99'	104' 7"	32' 1"

Abbreviations:
P&W—Pratt & Whitney Aircraft.
Wr—Wright Aeronautical Division.
All—Allison Division, GMC.

Footnotes:
[1] Figure is sea level rate of climb.
[2] Includes two cabin attendants

Lighter-Than-Air Craft

Manufacturer	Model	Name	Primary mission	No. of crew	No. of passengers	Envelope diameter, ft.	Overall length, ft.	Overall height, ft.	Number, description and maximum rating of powerplants
Goodyear Aircraft Corporation	ZSG-4		ASW	8		62.10	266.48	81.48	2 P&W R1340-6s, 600 hp.
	ZS2G		ASW	8		67.52	285.14	89.70	2 Wr R1300-4 6s, 700 hp.
	ZPG-2		ASW	14		75.42	342.65	94.68	2 Wr R1300-4 6s, 700 hp.
	ZPG-2W		AEW	21		75.42	342.65	105.24	2 Wr R1300-4 6s, 700 hp.
	ZPG-3W		AEW	21		85.1	403.4	117.8	2 Wr R1820-88 6s, 1,275 hp.
	TZ123,000 ("L")	Enterprise Type	Advertising and Fabric Research	1	6	39.6	148.1	54.5	2 Warner Scarab 6s, 145 hp.

Abbreviations:
AEW—Airborne Early Warning
ASW—Anti-Submarine Warfare
P&W—Pratt & Whitney Aircraft
Wr—Wright Aeronautical Division

Bell Helicopter Corp.	201	XH-13F	1	2	180	35' 1"	41' 8"	9' 5"	1,504	2,150	2,500	1 Con. Artouste I	200	95/S.L.	10,100	99	Derated engine
	47G	H-13G	1	2	465	35' 1"	41' 8"	9' 5"	1,435	2,350	2,350	1 AM 6V4-200-C32	200	99/S.L.	8,600	247	
	47G-2	H-13H	1	2	430	35' 1"	41' 8"	9' 5"	1,564		2,350	1 Lyc. VO435	200	100/S.L.	15,700	251	Derated engine
	47H		1	2	446	35' 1"	41' 6"	9' 3"	1,502	2,350	2,350	1 AM 6V4-200-C32	200	102/S.L.	9,900	219	
	47J	HUL-1	1	3	635	37' 2"	45' 4"	9' 4"	1,535	2,565	2,550	1 Lyc. VO435	220	105/S.L.	15,900	194	Derated engine
	61	H8L-1	4	...		51' 6"	70' 0"	14' 6"				1 P&W R2800-50	1,900	132/S.L.			Twin-tandem rotors
	200	XV-3	1	...		25' 0"	30' 0"	13' 6"				1 P&W R985	...	160/2500			Convertiplane
	204	XH-40	1	5	800	44' 0"	57' 0"	11' 1"	3,344	5,194	5,619	1 Lyc. XT53	700	152	19,000	202	Derated engine
Benson Aircraft Corp.	B-4		1	(1)	50	29' 0"	29' 0"	8' 0"	340	720		1 Nel. H50	40	62/S.L.		100	
	B-6		1	...	100	20' 0"	20' 0"	5' 4"	103	278	378	None					
	B-7		1	...	125	20' 0"	20' 0"	5' 10"	95	270	395	None					
	B-7W		1	...	90	20' 0"	20' 0"	7' 8"	130	305	400	None					
	B-7M		1	...	30	20' 0"	20' 0"	8' 10"	180	385	450	1 Nel. H30	40	71/S.L.		120	
Brantly Helicopter Corp.	B2		1	1	350	23' 8"	28' 7"	6' 10"	940	1,600	1,600	1 Lyc. VO360	170	110/S.L.		250	
Cessna Aircraft Co.	CH-1	YH-41	1	1	400	35' 0"	42' 6"	8' 6"	2,045	3,000	3,000	1 Con. FSO470	260	122/S.L.	13,200	290	
Convertawings, Inc.	A		1	0		19' 5"	35' 0"	10' 0"		2,200		2 Con. C90-12F	90				Four-rotor convertiplane
Doman Helicopters, Inc.	LZ5-1	YH-31	1	7	1,400	48' 0"	58' 9"	10' 5"	3,387	5,200	5,200	1 Lyc. SO580-A1B	400	76/1,000	4,000	350	
	LZ5-2		1	7	1,400	48' 0"	58' 9"	10' 5"	3,250	5,200	5,200	1 Lyc. SO580-A1B	400	105/1,000	4,000	380	
	D-11		1	7	1,800	48' 0"	58' 9"	10' 5"	3,135	5,200	5,200	1 Lyc. SO580-A1B	400	105/1,000	4,000	380	
Flettner Aircraft Corp.	220										100,000	Jet turbine					Crane competition
Glenview Metal Products Co.	R, S		1	1		32' 0"	33' 7"	7' 8"	1,150	1,655		1 Lyc. O290-D2	140	118/2,000	4,200	220	
Goodyear Aircraft Corp.	400R		1	0					275	475	520	1 JN RDHE	38	60/S.L.		50	Prototype only
Gyrodyne Co. of Amer., Inc.	GCA-41	XRON-1	1	0		18' 0"	18' 0"	8' 0"		500		1 Nel.	40				
Hiller Helicopters	UH-12C	H-23C	1	2	572	35' 0"	40' 6"	9' 6"	1,741	2,334	2,550	1 AM 6V4-200-C35	200	84/S.L.	2,500	120	
	UH-12D	H-23D	1	2	607	35' 0"	40' 6"	10' 1"	1,787	2,380	2,600	1 Lyc. VO435	250	91/S.L.	4,200	188	
	HJ-1	H-32	1	1	306	23' 0"	23' 0"	7' 11"	544	1,080	1,080	2 H. 8RJ2B	40	68/S.L.	3,000	32	Ramjet power
		XROE-1	1	0		18' 0"	18' 0"	7' 5"				1 Nel. H50	42				Rotorcycle
	Platform		1	0		5' 0"	6' 0"	7' 0"				2 Nel. H50	42				Testbed
Hughes Aircraft Div.	269		1	1		25' 0"	28' 3"	9' 4"	850	1,500		1 Lyc. O340-A1A	170	95/S.L.	7,000	170	
Kaman Aircraft Corp.	K-240	HTK-1	2	1		41' 0"	41' 0"	12' 3"	2,300	3,000	3,000	1 Lyc. O435-K1	250	86/S.L.	4,500	120	
	K-10		2			41' 0"	41' 0"	12' 3"		3,000	3,000	2 Boeing 502-3	190				Development project
	K-5		2			38' 0"	38' 0"	11' 6"		2,800	2,800	1 Boeing 502-2	190				Development project
	K-600	HOK-1	2	2	2,000	47' 0"	34' 2"	11' 8"	4,290	5,800	6,800	1 P&W R1340-48	600	110/8,000	12,000	220	
Kellett Aircraft Corp.	KH-15		1	0								2 RMI rockets	160				Research vehicle
	KH-17A		1	0								1 Jac. R755 B and 2 Lyc. O200-D2					Flying test bed
McDonnell Aircraft Corp.	82	XV-1	1	3		26' 0"	30' 0"	10' 0"				1 Con. R975-19, 3 pressure jets	550				Convertiplane
Nagler Helicopter Co., Inc.	160		1	0		30' 3"				750		1 McC 4318	70	90/S.L.	6,000		Test vehicle; co-axial
Omega Aircraft Co.	8B-12		1	4	1,000	39' 0"	39' 6"	13' 0"	3,050	4,500	4,500	2 AM 6A-335	210	103/S.L.	5,900	175	Prototype in test
Rotor Craft Corp.	RH-1		1	0	50+	18'	7' 6"	8' 0"	180	400+		RC R-1	25	80	12,000	30	Rocket power
Sikorsky Aircraft Div.	S-55C	H-19A	1-2	10	1,700	53' 0"	62' 7"	13' 4"	4,888	7,200	7,200	1 P&W R1340	600	101/S.L.	2,200	405	Also H-19C, HO4S-1, HRS-1 & -2
	S-55A	H-19B	1-2	10	2,100	53' 0"	62' 7"	13' 4"	5,188	7,500	7,900	1 Wr. R1300-3	700	110/S.L.	8,500	395	Also H-19D, HO4S-2, HO4S-3, HRS-3
	S-56	HR2S-1	2			72' 0"	82' 10"	17' 1"		28,500		2 P&W R2800-50	1,900				Also Army H-37A
	S-58	H-34A	2-4	18	4,000	56' 0"	65' 10"	14' 4"	7,650	12,500	13,300	1 Wr. R1820-84	1,525	134/S.L.	10,000	384	Also Navy HSS-1
	S-59	XH-39	1-2	2-3	800	35' 0"	41' 7"	9' 8"	2,200	3,625	3,625	1 Con. Artouste II	425	146/S.L.	18,500	288	Holds speed (156 mph.) and altitude records (24,500 ft.)
Transcendental Aircraft Corp.	1-G		1			17' 0"						1 Lyc. GO-290	160				Convertiplane test
Vertol Aircraft Corp.	PD-18	HUP-2	1	5-6	1,500	35' 0"	56' 11"	13' 2"	4,100	5,750	6,100	1 Con. R975-46	550	108/S.L.	7,000	490	
	PD-18	H-25A	1	5-6	1,500	35' 0"	56' 11"	12' 6"	3,928	5,750	6,100	1 Con. R975-46	550	108/S.L.	7,000	490	Also Navy HUP-3
		HUP-4	1									1 Wr. R1300-3	700				
		H-21A	1-2	14		44' 0"	86' 4"	16' 0"	8,300	11,200	14,500	1 Wr. R1820-103	1,150	140/S.L.	14,900	450	Power limited by transmission
	143	H-21B	1-2	20		44' 0"	86' 4"	16' 0"	8,600	13,300	15,000	1 Wr. R1820-103	1,425	140/S.L.	6,000	400	
	143	H-21C	1-2	20	4,500	44' 0"	86' 4"	16' 0"	8,600	13,300	15,000	1 Wr. R1820-103	1,425	140/S.L.	6,100	400	
		YH-16	2-3	40		82' 0"	134' 0"	31' 0"		30,000		2 P&W R2180	1,450				YH-16A has T38s

Engine abbreviations:

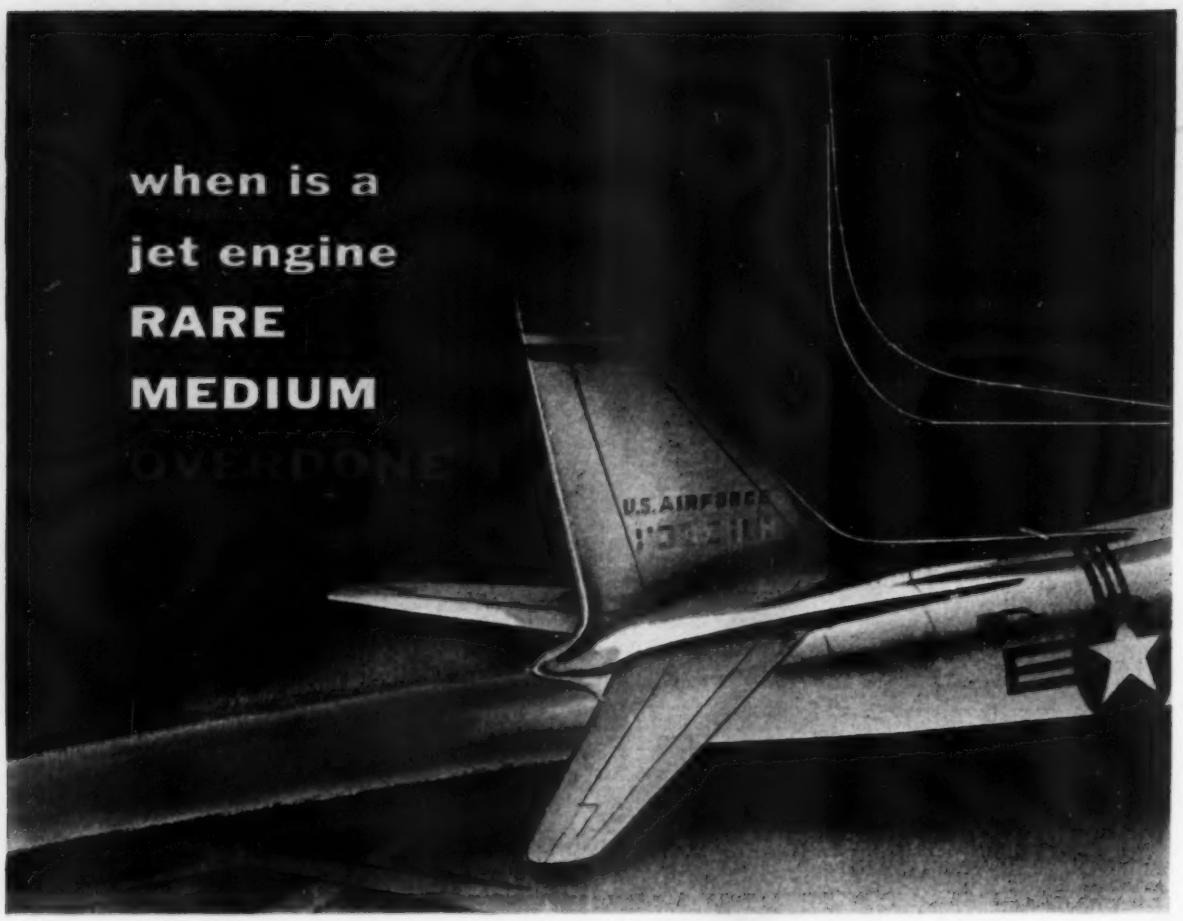
AM — Aircooled Motors (Franklin)
Con. — Continental Motors Corp.
H. — Hiller
Jac. — Jacobs Aircraft Engine Co.
JN — Johnson Motors
Lyc. — Lycoming Division
McC — McCulloch Motors
Nel. — Nelson
P&W — Pratt & Whitney Aircraft
RC — Rotor Craft
RMI — Reaction Motors, Inc.
WR. — Wright Aeronautical Division

Footnote: 1— lb. thrust

Acme	A-1	10	46′		30′		11′		260	4,100	8,550	1 Con. 420-M @ 1,200 lb.	480	370	43	650	650	1,650	150,000	
Aerocar, Inc. *Longview, Wash.*	Aerocar	2	34′		21′		7′	6″	190	1,500	2,050	1 Lyc. O320 @ 143 hp.	23	5	110+	50	650	350	300	25,000	Flying auto
Aero Design & Eng'g. Co. *Bethany, Okla.*	560A/L-26B	7	44′		35′	5″	14′	9″	242	4,145	6,000	2 Lyc. GO 480-D1A @ 275 hp.	156	206	68	1,100	1,050	1,050	74,500	
	(HC) 560A	7	44′		35′	5″	14′	9″	242		6,000	2 Lyc. GO 480-C1B6 @ 295 hp.	156	216	68			1,080	76,500	
	680 Super/L-26C	7	44′		35′	5″	14′	9″	242	4,330	7,000	2 Lyc. GSO 480-A1A-6 @ 340 hp.	223	260	71	1,575	1,630	1,600	89,500	
Aero-Flight Aircraft Corp. *Long Beach, Calif.*	Streak-165	2	25′	3″	22′	4″	8′	3″			1,695	1 AM @ 165 hp.	40	219	57	429	480	1,090		
Baumann Aircraft Corp. *No. Hollywood, Calif.*	Brigadier B-290	5	41′		29′		11′		209	2,750	4,050	2 Con. C145-2HP @ 145 hp.	78	190	57	850	500	750	44,500	
Bee Aviation Associates, Inc. *San Diego, Calif.*	Wee Bee	1	18′	0″	14′	2″	5′	0″	44	210	410	1 Kirk. O45-35 @ 30 hp.	2	5	82	45	800	850	80		Prone pilot
	Honey Bee	1	28′	0″	16′	10″	7′	8″	96	610	860	1 Con. A65 @ 65 hp.	8	8	120	45	700	800	240		
	Queen Bee	4	32′	10″	22′	1″	8′	6″	130	1,190	2,150	1 Lyc. O320 @ 150 hp.	36	175	55	700	700	600	10,000		
Beech Aircraft Corp. *Wichita 1, Kan.*	Super 18 (E18S)	8	49′	8″	35′	2″	9′	6″	361	6,050	9,300	2 P&W R985-AN14B @ 450 hp.	275	234		1,800	1,700	1,626	106,975	
	Bonanza H35	4	32′	10″	25′	2″	6′	6″	178	1,833	2,900	1 Con. O470G @ 240 hp.	39	206	57	670	400	1,170	22,650	
	Twin Bonanza:																			
	D50	6	45′	3″	31′	6″	11′	4″	277	4,070	6,300	2 Lyc. GO 480 @ 295 hp.	134	214	71	1,260	1,455	1,650	77,000	
	E50	6	45′	3″	31′	6″	11′	4″	277	4,440	7,000	2 Lyc. GSO 480-A1A6 @ 340 hp.	180	240	80	1,250	1,840	1,650	88,000	
	Travel Air 95	4	37′	9″	25′	4″	9′	6″	194		4,000	2 Lyc. O360 @ 180 hp.	114	207	66		...	1,370		
Call Air *Afton, Wy.*	A-4 (Ag.)	2	33′	1″	23′	5″	7′	0″	180	975	2,150	1 Lyc. O320-A2A @ 150 hp.	25	110	43	750	400	325	6,850	
Cessna Aircraft Co. *Wichita, Kan.*	182	4	36′	0″	26′	0″	8′	6″	175	1,500	2,650	1 Con. O470-L @ 230 hp.	65	165				805	13,975	
	180	4	36′	0″	26′	0″	7′	6″	175	1,555	2,650	1 Con. O470-K @ 230 hp.	65	170					13,250	
	310	5	36′	0″	27′	0″	10′	5″	175	2,900	4,600	2 Con. O470-M @ 240 hp.	100	220+				1,000	51,950	
	172	4	36′	0″	25′	0″	8′	6″	175	1,200	2,200	1 Con. O300-A @ 145 hp.	42	135					8,975	
	320	11	55′		41′	6″	16′	7″	340	10,000	15,000	4 Con. GSO 526-A @ 350 hp	535	282	..		3,050	1,700	375,000	Flight test.
Champion Aircraft *St. Paul, Minn.*	Champion	2	35′	2″	22′	6″	6′	10″	170	800	1,450	1 Con. C90-12 @ 90 hp.	28	115	44					Also tricycle gear.
Colonial Aircraft Corp. *Sanford, Me.*	Skimmer	3	34′	0″	23′	6″	8′	10″	152	1,425	2,150	1 Lyc. O320 @ 150 hp.	80	128	50	1500W 500L	400	600	16,250	Amphibian
Fairchild Aircraft Div. *Hagerstown, Md.*	M-185	10	57′*		50′*							4 Fair. J83 @ 2,000 lb.*	1,850	550*				2,500*	800,000	Or GE J85s
	F-27 Friendship	42	95′		76′		26′	6″	751	21,645	34,520	2 R-R Dart 500 @ 1,600 shp.		300*		3,850	3,000	2,250		Turboprops
Fletcher Aviation *Rosemead, Calif.*	Defender	1	30′	0″	21′	11″	6′	3″	150	1,100	1,917	1 Con. E225 @ 250 hp.	60	187	48					
	Utility	5	42′	0″	31′	10″	9′	4″	294	1,870	3,500	1 Con. O470-E @ 225 hp.	11		48	870		410	24,920	
Florida Flight Eng'g. Corp. *Miami 48, Fla.*	Mid-Jet BT-1	2	18′	4″	18′	6″			66	505	1,050	1 Tur. Palas @ 340 lb. t.	50	150	68	3,200	2,500			
Goodyear Aircraft Corp.	GA22-A Drake	4	38′		29′	8″	10′	2″	209	1,950	3,000	1 Con. E225-8 @ 225 hp.	61	148	53	750	700	675		Amphibian
Helio Aircraft Corp. *Norwood Mass.*	Courier	4	39′	0″	30′	0″	8′	10″	231	1,920	3,000	1 Lyc. GO435-C2B @ 260 hp.	61	157	30	895	495	600	24,500	
	Strato Courier	2	39′	0″	30′	8″	8′	10″	231	2,080	3,000	1 Lyc. GSO480 A1A6 340 hp.	82	194	30	320	495	1,000	$40,000	
Larson Aero Develop't. *Concord, Calif.*	D-1	1	33′						315	1,900			30							Still Experimental
	F-12	1	17′						85	500		1 Con. C-85 @ 85 hp.	12							Kit
Monocoupe Aircraft *Melbourne, Fla.*	Meteor Mk. 2	4	32′		25′		6′	1″	160	1,750	3,100	2 Lyc. O320 @ 150 hp.	90	193	58	600	550	800	30,000	
Mooney Aircraft, Inc. *Kerrville, Tex.*	Mark 20	4	35′	0″	23′	2″	8′	5″	167	1,400	2,450	1 Lyc. O320 @ 150 hp.	50	177	57			1,000	13,750	
Northern Aircraft, Inc.	Cruisemaster	4	34′	2″	22′	11″	6′	2″	161	1,675	2,700	1 Con. O470K @ 230 hp.	50	226	46			800	15,972	Formerly Bellanca
Piper Aircraft Corp. *Lock Haven, Pa.*	PA-18A	1	35′	3″	22′	5″	6′	7″	178 5	1,000	2,070	1 Lyc. O320 @ 150 hp.	36	105		950	875	300		Agricultural Duties
	PA-18 "150"	2	35′	3″	22′	5″	6′	7″	178 5	930	1,750	1 Lyc. O320 @ 150 hp.	36	130		800	725	490		
	PA-18 "95"		35′	3″	22′	5″	6′	7″	178 5	800	1,500	1 Con. C90 @ 90 hp.	18	112		750	800	390		Trainer
	PA-22 Tri-Pacer		29′	3″	20′	6″	8′	3″	147 5	1,100	2,000	1 Lyc. O320 @ 150 hp.	30	139	69			800	7,840	Three models
	PA-23 Apache		37′	0″	27′	1″	9′	5″	204	2,180	3,500	2 Lyc. O320 @ 150 hp.	72	180	52			900	34,990	Three models
	PA-24 Comanche	4										1 Lyc. O360 @ 180 hp.							13,500	Also 250-hp. Lyc.
	PA-25	1																		Agric. testbed
Snow	S-2	1	38′		27′	8″	8′	6″	285	1,944	3,600	1 Con. R670 @ 220 hp.	50	120	45			400	6,400	Agricultural
Stits Aircraft *Riverside, Calif.*	Flut-R-Bug	2	26′	0″	18′	0″	6′	0″	130	570	1,031	1 Con. @ 65 to 90 hp.	131	100	38	250				Sold in kits
	Sky-Coupe	2	25′		18′		6′		130	600	1,150	1 Con. @ 65 to 90 hp.	20	150	45	300				
Streak-Aero Corp. *Hollydale, Calif.*	Streak 225	2	25′	3″	22′	6″	8′	1″			1,965	1 Lyc. O435-A2 @ 225 hp.	70	238	61	490	500	1,350		
Taylorcraft, Inc. *Conway, Pa.*	Zephyr	4	34′	8″	24′	4″	7′	2″	179	1,700	2,750	1 Con. O470J @ 225 hp.	66	160	65	450	700	750	13,945	
	Topper	1	34′	8″	24′	4″	7′	2″	179	1,635	2,750	1 Con. O470J @ 225 hp.	44	115	70	900	900	400		Agricultural duties
	Seabird	4	34′	8″	24′	4″	7′	2″	179	2,000	3,040	1 Con. O470J @ 225 hp.	66	145	70	700	1,000	650	13,990	Float plane
Transland Company *Torrance, Calif.*	Ag-2	1	42′	0″	28′	5″	9′	8″	321	3,038	6,000	1 P&W R985 @ 450 hp.	125	150	57	900	600		28,500	Farm & forest duties
Trecker Aircraft Corp. *Milwaukee 14, Wis.*	Royal Gull	5	44′	4″	35′	6″	13′	0″	270	4,400	6,000	2 Lyc. GO480-B1B @ 270 hp.	190		75	965	755	1,000		Amphibian
	Super Gull 200	5	44′	5″	35′	6″	13′	0″	270		6,600	2 Lyc. GSO480-A1A6 @ 340 hp.	190	208		1,460	1,880	900+	89,925	Supercharged engine

Abbreviations:
AM — Aircooled Motors
Con. — Continental Motors Corp.
Fair. — Fairchild
Kiek. — Kiekhaefer
Lyc. — Lycoming Division
P&W — Pratt & Whitney Aircraft
RR — Rolls-Royce
Tur. — Turbomeca
***** — Approximate

Note:
All data were supplied by the manufacturers. Prices and other figures may be subject to change. In particular, CAA field length figures appear to be in some cases only rolling distances on the ground.



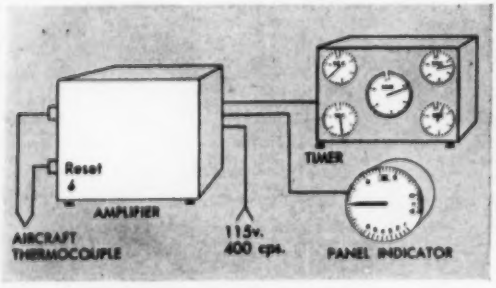
AVIEN'S TTR keeps hot jets "hot"... and safe

You may be able to plot a jet engine's overheat limits accurately enough on paper . . . but what actually happens in flight? When is the serviceability range exceeded? When does overhaul . . . or replacement . . . become a must? The wrong answers can mean a lost engine, plane . . . and crew.

Getting the right answers every time is the job of TTR . . . Avien's Time-Temperature Recorder for jet engines. Providing both panel indication of operating temperature, plus a visual record of engine overheat time, it tells pilot . . . and ground crew . . . exactly when engines approach the dangerous "overdone" region. The result is improved flight safety at high thrust operation, plus simplified maintenance and reduced aircraft down time.

A product of Avien's unsurpassed experience in designing and manufacturing engine temperature instrumentation for high performance aircraft, the TTR system is equally applicable to turbo-jet and turbo-prop engines. Employing Avien's servo-driven, self-balancing gaging design, it monitors critical temperatures within ±0.5%, detects and logs as little as one second of overheat. Designed to meet the specialized requirements of today's . . . and tomorrow's . . . aircraft, it can monitor a single temperature limit, a multiple group, or any range of engine temperatures.

Now specified by the USAF for all F86D "Sabrejets," the TTR system brings to both military and commercial flight a precision tool for resolving the conflicting requirements of high efficiency and maximum flight safety. Perhaps it can help you solve a tough engine temperature problem. For more information, write Sales Engineering Department.



Typical TTR (Time-Temperature Recorder) for jet fighter records length of time engine has exceeded any one, or any combination, of five critical temperatures. Using existing aircraft thermocouple harness, the system requires neither shielded leads nor special size wiring. Flag in indicator warns pilot when overheat temperature has been reached. Flag re-set is located in amplifer and is accessible only to ground crew. Overheat warning remains in "danger" position until engine has been inspected for possible turbine-wheel damage.

Avien

PRECISION INSTRUMENTS AND CONTROL SYSTEMS
58-15 NORTHERN BOULEVARD
WOODSIDE 77, NEW YORK

U.S. Reciprocating Engines

Manufacturer and Address	Designation		No. Cyl.	Arr.	Drive	Power Ratings					Fuel Grade	Dry Weight, lb.	Length x Width x Height, in.	Propeller Shaft Diameter, in.	Specific Weight, lb./hp.
						Take-off hp.	at r.p.m.	Max. Cont. hp.	at r.p.m.	Rated Alt., ft.					
Aircooled Motors, Inc. *Syracuse, N. Y.*	4A4-100-B3		4	Ho	Direct	100	2,550				80				200
	6A4-150-B3		6	Ho	Direct	150	2,600				80				278
	6A4-165-B3		6	Ho	Direct	165	2,800				80				278
	6V4-178-B32[1], B33,[1] 0335-3, -4		6	Vo	Direct	178	3,000				80				294
	6AG4-185-B12		6	Ho	G 632:1	185	3,100				80				232
	6A4-200-C6		6	Ho	Direct	200	3,100				91				307
	6V4-200-C32[1], C33[1], 0335-5, -6		6	Vo	Direct	200	3,100				91				297
	6V6-245-B 16[1] O 425-1		6	Vo	Direct	245	3,275				80				372
	6V-335-A,-B		6	Vo	Direct	210	3,100				91				295
Avco Manufacturing Corp. **Lycoming Division** *Stratford, Conn.*	O-235-C1		4	Ho	Direct	115	2,800	80	2,350	6,500	80	22 53x32			237
	O-290-D2B		4	Ho	Direct	140	2,800	100	2,350	6,500	80/87	22 81x32 24			264
	O-320		4	Ho	Direct	150	2,700	110	2,450	7,000	80/87	23 12x32 24			272
	O-340-A1A		4	Ho	Direct	170	2,700	125	2,450	7,000	91/96	24 68x32 55			278
	O-340-B1A		4	Ho	Direct	160	2,700	120	2,450	7,000	80/87	24 68x32 55			275
	O-360-A1A		4	Ho	Direct	180	2,700	135	2,450	7,500	91/96	24 68x33 57			282
	O-360-B1A		4	Ho	Direct	168	2,700	125	2,450	7,500	91/96	24 68x33 57			279
	O-435-A		6	Ho	Direct	190	2,550	140	2,300	7,000	80	29 59x32 24			392
	VO-435-A1C		6	Vo	Direct	260	3,400	200	3,200	7,000	80/87	25 19x33 32			396
	VO-435-A1D		6	Vo	Direct	260	3,400	200	3,200	7,000	80/87	25 19x33 32			390
	GO-435-C2D2		6	Ho	Gear	260	3,400	180	2,750	6,000	80/87	28 02x33 12			430
	GO-480-B1A6		6	Ho	Gear	270	3,400	195	2,750	7,000	80/87	28 02x33 12			432
	GO-480-B1D		6	Ho	Gear	270	3,400	195	2,750	7,000	80/87	28 02x33 12			432
	GO-480-C1B6		6	Ho	Gear	295	3,400	210	2,750	7,000	100/130	26 34x33 12			462
	GO-480-C1D6		6	Ho	Gear	295	3,400	210	2,750	7,000	100/130	28 02x33 12			432
	GO-480-C2C6		6	Ho	Gear	295	3,400	210	2,750	6,500	100/130	28 02x33 12			448
	GO-480-C2D6		6	Ho	Gear	295	3,400	210	2,750	6,500	100/130	28 02x33 12			442
	GO-480-D1A		6	Ho	Gear	275	3,400	197	2,750	7,000	80/87	26 34x33 12			453
	GO-480-F1A6		6	Ho	Gear	275	3,400	197	2,750	7,000	80/87	28 02x33 12			436
	GSO-480-A1A6		6	Ho	Gear	340	3,400	240	2,750	10,000	100/130	33 08x33 12		11 27	495
	GSO-580-D, 0580-1		8	Ho	G 642:1	400	3,300	260	2,750	11,500	100/130	34 22x33 18		7 91	604
	SO-580-A1B		8	Ho	Direct	400	3,300	280	3,000	11,000	100/130	24 49x33 12		7 91	578
	VSO-580-A1A* 0580-3		8	Ho	Direct	400	3,300	280	3,000	11,000	100/130	30 78x33 18		7 91	591
Continental Motors Corp. *Muskegon, Mich.*	A65-8		4	Ho	Direct	65	2,300				80/87				171
	C85-12F		4	Ho	Direct	85	2,575				80/87				182
	C90-12F		4	Ho	Direct	95	2,625				80/87				186
	O300 (C145-2)		6	Ho	Direct	145	2,700				80/87				311
	O470-E		6	Ho	Direct	225	2,600				80/87				395
	O470-G		6	Ho	Direct	240	2,600				91/96				466.5
	O470-H		6	Ho	Extended Direct	240	2,600				91/96				510
	O470-J		6	Ho	Direct	225	2,550				80/87				415
	O470-K		6	Ho	Direct	230	2,600				80/87				438
	O470-L		6	Ho	Direct	230	2,600				80/87				438
	O470-M		6	Ho	Direct	240	2,600				91/96				450
	SO470-A		6	Ho	Direct	265	2,600				100/130			10 36	522
	FSO526-A		6	Ho	G 10 04	270	3,200				91/96			10 86	568
	GSO526-A		6	Ho	G 688:1	320	3,000				91/96				560
	GSO526-B		6	Ho	G 688:1	400	3,200				100/130				548
Pratt & Whitney Aircraft Div. **United Aircraft Corp.** *East Hartford, Conn.*	R2000-D5		14	Rad	G 500	1,450	2,700	1,200	2,550	6,400	100/130	49 10			1,585
	R2000	28D13-G	14	Rad	G 500	1,450	2,800	1,200	2,550	5,000	100/130	49 10			1,605
	R2800-CB3		18	Rad	G 450:1	2,400	2,800	1,900	2,600	8,500	100/130	52 80			2,357
	R2800-CB4		18	Rad	G 450:1	2,500	2,800	1,900	2,600	8,500	108/135	52 80			2,357
	R2800-CB16		18	Rad	G 450:1	2,400	2,800	1,900	2,600	8,500	100/130	52 80			2,390
	R2800-CB17		18	Rad	G 450:1	2,500	2,800	1,900	2,600	8,500	108/135	52 80			2,390
Wright Aeronautical Div. **Curtiss-Wright Corp.** *Wood-Ridge, N. J.*	749C18BD1		18	Rad	G 4375:1	2,500	2,800	1,470	2,400	11,000	100/130	55 6		6 46[4]	2,944
	826C9HD3, & 5	R1820-76A,-76B	9	Rad	G 666:1	1,425	2,700				100/130	54 95		7 21[3]	1,380
	836C18CA2	R3350-26WB	18	Rad	G 4375:1	2,700	2,900	1,900	2,600	17,000	115/145	55 6		6 46[4]	2,932
	853C7BA1	R1300-1A	7	Rad	G 5625:1	800	2,600				91/98	50 45		7 21	1,065
	856TC18DB1, 2[5]	R3350-30WA	18	Rad	G 4375:1	3,500	2,900				115/145	56 6		6 46[4]	3,408
	863C9HD1	R1820-103	9	Rad	Direct	1,425	2,700				100/130	54 95		7 21[3]	1,380
	865C7BA1	R1300-2	7	Rad	Direct	800	2,600				91/98	50 45		7 21	1,056
	867C9HE1, 2	R1820-82	9	Rad	G 5625:1	1,525	2,800				115/145	55 74		7 21	1,445
	871C7BA1[3]	R1300-3	7	Rad	Direct	800	2,600				91/98	50 45		7 21	1,090
	872TC18DA1	R3350-34	18	Rad	G 4375:1	3,250	2,800				115/145	56 6		6 46[4]	3,557
	878TC18EA1	R3350-32a	18	Rad	G 4375:1	3,700	2,900				115/145	56 6		6 46[4]	3,458
	895C9HE1	R1820-84	9	Rad	Direct	1,525	2,800				115/145	55 74		7 21	1,405
	896C9HD1	R1820-86	9	Rad	G 666:1	1,425	2,700				100/130	55 27		7 21[3]	1,385
	923TC18DA1	R3350-91	18	Rad	G 4375:1	3,250	2,800				115/145	56 6		6 46[4]	3,620
	932TC18EA2		18	Rad	G 355:1	3,400	2,900				115/145	56 6		6 46[4]	3,708
	957C7BA1		7	Rad	G 5625:1	800	2,600	490	2,130	10,500	91/98	50 45		7 21	1,065
	960C9HE1		9	Rad	G 5625:1	1,475	2,800	950	2,400	13,000	100/130	54 95		7 21	1,390
	972TC18DA1, 2[6]		18	Rad	G 4375:1	3,250	2,800	1,910	2,400	11,800	115/145	56 6		6 46[4]	3,514
	978C18CB1		18	Rad	G 4375:1	2,800	2,900	1,600	2,400	12,500	115/145	56 6		6 46[4]	3,029
	976C9HE1		9	Rad	G 5625:1	1,535	2,800	950	2,400	12,200	100/130	55 75		7 21[3]	1,460
	977C9HD1		9	Rad	Direct	1,425	2,700				100/130	55 25		7 21[3]	1,349
	918TC18EA1		18	Rad	G 4325:1	3,700	2,900	1,910	2,400	13,500	115/145	56 59		6 46[4]	3,581
	982C9HE1		9	Rad	G 5625:1	1,525	2,800				115/145	55 75		7 21	1,455
	987C9HD1		9	Rad	G 666:1	1,425	2,700	975	2,500	18,300	100/130	54 95		7 21[3]	1,371
	988TC18EA-1[7]		18	Rad	G 4375:1	3,400	2,900	1,910	2,400	13,500	115/145	56 59		6 46[4]	3,699
	988TC18EA2		18	Rad	G 355:1	3,400	2,900	1,910	2,400	13,500	115/145	56 59		6 46[4]	3,745
	989C9HE1, 2[3]		9	Rad	Direct	1,525	2,800				115/145	55 74		7 21	1,405

G — Geared.
Ho — Horizontally opposed.
Rad — Radial.
SL — Sea level.
Vo — Vertically opposed.

[1] For helicopter installation.
[2] Or 10.14:1.
[3] Or 8.89:1.
[4] Or 8.67:1.
[5] 856TC18DB2 (R3350-38W) is similar but has take-off power of 3,250 hp. and dry gross weight of 3,445 lb. 856TC18DB1 (R3350-85) and 856TC18DB2 (R3350-89) is similar to -30WA but weighs 3,436 lb. dry. Some have manifold absolute pressure regulator.
[6] DA3 is identical to DA1 except for incorporation of increased capacity main bearings, improved pistons and improved PRT cooling air impellers. DA4 identical to DA2 except for differences as listed for DA3 and DA1 engines.
[7] EA3 is same as EA1 except for modified baffles and fuel injection line routing. EA6 is same as EA4 except for differences listed for EA3 and EA1. EA5 is similar to EA2 except for improvements which permit increased cruise power.

Lockheed C-130's paradrop 29,000 pound loads on-a-dime, in seconds

LOCKHEED'S C–130 HERCULES, NEW PROPJET "STRONGMAN" OF TACTICAL AIR COMMAND'S 18TH AIR FORCE, CAN AIRLIFT MORE FIGHTING MEN AND EQUIPMENT FARTHER, FASTER, AND AT LOWER COST THAN ANY COMBAT CARGO CARRIER NOW IN SERVICE.

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LOCKHEED *means leadership*

LOCKHEED GEORGIA DIVISION: *(U.S. Air Force Plant No. 6, Marietta, and Georgia Nuclear Laboratory, Dawsonville)* PROPJET C-130 HERCULES COMBAT CARGO CARRIER • B-47 MODERNIZATION • NUCLEAR-POWERED AIRCRAFT RESEARCH & DEVELOPMENT

Manufacturer	Model designation	Aircraft name	Primary mission	Max. No. of crew	Max. No. of passengers	Overall wingspan, ft.	Overall length, ft.	Maximum height, ft.	Wing gross area, sq. ft.	Weight empty, lb.	Gross weight, lb.	Number, make, model and max. rating of powerplants	Max. speed, mph.
ARGENTINA													
Fabrica Militar de Aviones	I. A. 33	Pulqui 2	Fighter	1	0	34.8	38.1	10.4	.....	7,920	12,100	1 R-R Nene 2 @ 5,000 lb. t.	654
	I.A. 35	Justicialista del Aire	Multi	3	8	64.0	45.8	.....	.....	7,700	12,500	2 I.A. 3 190 II Indio @ 620 hp.	220
AUSTRALIA													
Commonwealth Aircraft Corp. Pty., Ltd.	C.A. 25	Winjeel	Trainer	3	0	38.8	28.0	9.0	249	3,280	4,235	1 P&W R985-AN 2 @ 450 hp.	187
	C.A. 27	Sabre Mk. 30	Fighter	1	0	37.1	37.5	14.7	288	11,000	20,000	1 R-R Avon 30 @ 7,500 lb. t.	700
Government Aircraft Factories	.....	Canberra 20	Bomber	2	0	64.0	65.5	15.6	960	.....	51,000	2 R-R Avon	...
CANADA													
Avro Aircraft, Ltd.	CF-100 Mk. 5	.....	Interceptor	2	0	....	54.0	14.5	.....	.....	.....	2 Orenda 11 @ 7,000 lb. t.	...
	CF-105	.....	AW Ftr.	.....	.....	54.0	.....	.....	.....	.....	82,000	2 Orenda PS13 @ 20,000 lb. t.	M>1
Canadair, Ltd.	.....	Sabre 6	Fighter	1	0	37.0	37.5	14.7	.....	.....	.....	1 Orenda 14 @ 7,200 lbs t.	700
	CP-107	Argus	Reconnaissance	15	0	142.3	128.3	36.7	2,075	.....	145,000	4 Wright R3350 988 TC 18 EA 1	290
	T-33A	Silver Star	Trainer	2	0	42.5	37.7	11.7	.....	.....	.....	2 R-R Nene 10 @ 5,100 lb. t.	...
De Havilland Aircraft of Canada, Ltd.	D.H.C. 2	Beaver	Transport	2	5	48.0	30.3	10.5	250	2,950	5,100	1 P&W R985 @ 450 hp.	163
	D.H.C. 3	Otter	Transport	2	12	58.0	41.8	13.0	375	4,368	8,000	1 P&W R1340 @ 600 hp.	160
	D.H.C. 4	Caribou	Transport	2	20	...	...	...	...	...	...	2 P&W R2000 or Wr R1820	...
FRANCE													
Construction Aeronautiques du Bearn	GY-30	Supercab	Pers.	1	1	27.0	18.0	5.6	110.8	880	1,350	1 Con. C 90 @ 90 hp.	175
	GY-20	Minicab	Pers.	1	1	27.0	18.0	5.5	109.2	594	1,057	1 Con. A65 @ 65 hp.	112
Avions Boisavia	B-605	Mercury	Pers.	1	3	37.5	23.5	7.5	194	1,430	2,575	1 Snecma 4LO2 @ 170 hp.	155
	B-250	Anjou	Pers	1	4	42.0	23.3	.....	.....	2,000	4,120	2 Snecma 4LO2 @ 170 hp.	155
S. A. des Ateliers d'Aviation Louis Breguet	763	Deux Ponts	Transport	3	107	140.8	94.9	31.4	1,965	68,150	113,500	4 P&W CA-18 @ 2,400 hp.	272
Generale Aeronautique Marcel Dassault	M. IV A	Mystere IV A	Fighter-Bomber	1	0	36.7	42.4	14.5	344	12,492	17,000	1 H.S. Verdon @ 7,700 lb. t.	M<1
	SM. B. 2	Super Mystere	Fighter-Bomber	1	0	34.4	46.1	14.9	.....	15,300	.....	1 Snecma Atar 101 G-2 @ 9,700 lb. t. w/a	746
	Etendard IV	Etendard IV	Fighter-Bomber	1	0	.....	.....	.....	.....	.....	.....	1 Snecma Atar 101 E-4 @ 8,150 lb. t.	M=1
	Etendard VI	Etendard VI	Fighter-Bomber	1	0	.....	.....	.....	.....	.....	.....	1 Bristol Orpheus @ 4,850 lb. t.	M<1
	Mirage I	Mirage I	Interceptor	1	0	.....	.....	.....	.....	.....	.....	2 M.D. 30 Viper @ 2,200 lb. t. +1 SEPR rocket	M>1
	Mirage III	Mirage III	Interceptor	1	0	.....	.....	.....	.....	.....	.....	1 Snecma Atar 101 G-1 @ 9,700 lb. t.	M>1
Avions Hurel-Dubois	H.D. 321	.....	Transport	3	44	147.6	78.3	27.6	1,075	24,800	41,200	2 Wright R1820 @ 1,525 hp.	206
	H.D. 34	.....	Photo	7	0	147.6	77.5	27.6	1,075	26,300	42,600	2 Wright 982 C9HE2 @ 1,475 hp.	206
Farman	.....	.....	Monitor 3	2	0	32.7	23.6	7.2	151	1,232	1,804	1 Snecma 4L26 @ 170 hp.	150
Ets Fouga & Cie.	C.M. 170R	Magister	Trainer	2	0	37.3	33.0	9.2	188	4,280	6,160	2 Turb. Marbore 2 @ 880 lb. t.	455
Rene LeDuc	O. 21	.....	Fighter	1	0	38.2	40.2	9.1	.....	8,360	13,200	1 LeDuc rj. @ 44,000 lb.t.	655
Soc. Max Holste	M.H. 1521	Broussard	Pers.	1	5	45.0	28.0	9.3	273	3,190	5,500	1 P&W R985 @ 450 hp.	175
Soc. Morane-Saulnier	M.S. 733	Alcyon	Trainer	3	0	37.0	31.1	11.4	235	2,810	3,850	1 Potez 6DO2A @ 240 hp.	164
	M.S. 760	Paris	Business	4	0	33.3	32.9	8.6	194	4,400	7,600	2 Turb. Marbore 2 @ 880 lb. t.	405
Soc. Industrielle pour l'Aeronautique	S. 200	Minijet	Trainer	2	0	26.2	16.9	5.9	103	1,090	1,805	1 Turb. Palas @ 350 lb. t.	240
	S. 300	Primijet	Trainer	2	0	26.2	22.1	8.5	103	1,155	1,935	1 Turb. Palas @ 350 lb. t.	225
	S. 1000	Coccinelle	Pers.	2	.....	29.6	18.8	8.2	139	815	1,355	1 Con. C 90-12F	124
Societe Payen-Aviations	PA-49	.....	Exp.	1	0	17.0	18.9	7.2	121	1,605	1,430	1 Turb. Palas @ 350 lb. t.	310
Soc. des Avions & Moteurs Henri Potez	Potez 75	.....	Attack	3	0	42.7	32.9	8.9	247	3,960	5,280	1 Potez 8D32 @ 450 hp.	175
Soc. Nat. de Constructions Aeronautiques du Nord	NC-856A	Norvigie	Obs.	3	0	39.6	25.0	7.2	192	1,485	2,530	1 Snecma Regnier 4LO4 @ 147 hp.	120
	Nord 2501	Noratlas	Trans.	3	42	107.0	72.0	10.1	1,063	28,600	48,400	2 Snecma Hercules @ 2,040 hp.	275
	Nord 3200	.....	Trainer	2	0	32.0	26.3	10.0	....	2,000	2,700	1 Salmson 8 AS @ 260 hp.	175
	Nord 1405	Gerfaut	Fighter	1	0	21.9	36.9	11.6	280	.....	.....	1 Snecma Atar	...
	Nord 1502	Griffon	Interceptor	1	0	21.5	32.6	.....	.....	.....	9,000	1 Snecma Atar 101-G @ 9,700 lb. t.	M>1

Abbreviations:

AW — All-weather
Con. — Continental
hp. — Horsepower
HS — Hispano-Suiza
lb. t. — Pounds thrust
M>1 — Supersonic
M<1 — Subsonic
P&W — Pratt & Whitney
R-R — Rolls-Royce
Turb. — Turbomeca

Sud-Est Aviation	S.E. 210	Caravelle	Trans.	4	70	112 5	104 8	28 5	1,579	49,500	90,400	2 R-R Avon 6r 10,500 lb. t.	465
	S.E. 5000	Baroudeur	Fighter	1	0	32 9	44 3	11 7	272	10,260	13,945	1 Snecma Atar 101D 6r 6,160 lb. t.	650
		Aquilon	Fighter	2	0	43 0	36 8	8 9		10,750	14,950	1 DH Ghost 6r 4,840 lb. t.	585
Ouest Aviation	S.O. 4050	Vautour	Attack	2	0	50	50	15	485		30,000	2 Snecma Atar 101E3 6r 7,720 lb. t.	680
	S.O. 9000	Trident	Fighter	1	0	25	42		177		12,000	3 SEPR 25 rockets 6r 9,900 lb. t.	M >1
GREAT BRITAIN													
Sir W. G. Armstrong-Whitworth Aircraft, Ltd.		Sea Hawk F.G.A. 6	Fighter	1	0	39 0	40 0					1 R-R Nene	
Auster Aircraft, Ltd.	J5B	Autocar	Pers.	1	3	36 0	23 2	6 5	185		2,400	1 DH Gipsy Major 1 6r 130 hp.	117
	J5F	Aiglet	Trainer	1	3	32 0	23 2	6 5	164	1,380	2,200	1 DH Gipsy Major 1 6r 130 hp.	125
	A.O.P. Mk. 6		Obs.	2	0	36 0	23 8	8 6	185	1,417	2,105	1 DH Gipsy Major 7 6r 145 hp.	123
	A.O.P. Mk. 9		Obs.	3	0	36 5	23 6	8 9	198	1 558	2,100	1 BL Bombardier 6r 180 hp.	127
	B8	Agricola	Agricultural	1	2	42 0	27 5	8 3	254 7		3,280	1 Continental O-470-M 6r 240 hp.	
Aviation Traders, Ltd.		Accountant	Trans.	2	28	82 5	60 5	24 1	632	14,823	28,000	2 R-R Dart 6	290
Blackburn & General Aircraft, Ltd	G.A.L. 60	Beverley	Trans.	4	162	162 0	99 5	37 5	2,916	84,740	143,000	4 Bris. Centaurus 6r 3,150 hp.	243
		Universal	Trans.	2	155	162 0	99 5	37 5	2,916	81,740	143,000	4 Bris. Centaurus 6r 3,150 hp.	243
Bristol Aircraft	175	Britannia 100	Trans.	9	92	142 3	114 0	36 7	2,075	81,388	155,000	4 Bristol Proteus 705 6r 3,960 eshp.	370
	175	Britannia 300	Trans.	9	101	142 3	124 3	36 7	2,075	82,827	160,000	4 Bristol Proteus 755 6r 4,120 eshp.	400
	175	Britannia 310	Trans.	9	93	142 3	124 3	36 7	2,075	82,537	175,000	4 Bristol Proteus 755 6r 4,120 eshp.	400
	175	Britannia 320	Trans.	9	132	142 3	124 3	36 7	2,075	82,537	175,000	4 Bristol Proteus 755 6r 4,120 eshp.	410
	175	Britannia 250	Pass./Cargo	9	84	142 3	124 3	36 7	2,075	83,715	175,000	4 Bristol Proteus 755 6r 4,120 eshp.	400
Boulton Paul Aircraft, Ltd.	P. 108A	Balliol T. 2	Trainer	2	0	35 1	39 1	12 5	250	6,730	8,410	1 R-R Merlin 35 6r 1,280 hp.	292
	P. 111A		Exp.	1	0	33 5	26 1	12 6				1 R-R Nene	
The de Havilland Aircraft Co. Ltd	D.H. 115	Vampire Trainer	Trainer	2	0	38 0	34 5	6 5	261		11,150	1 DH Goblin 35 6r 3,500 lb. t.	549
	D.H.C. 1	Chipmunk Mk. 20	Trainer	2	0	34 3	25 4	7 0	173	1,425	2,100	1 DH Gipsy Major 8 6r 145 hp.	138
	D.H. 112	Venom Mk. 3	AW F't'r.	2	0	41 6	36 6	6 5				1 DH Ghost	
	D.H. 112	Venom F.B. Mk. 4	Fighter	1	0	41 6	33 0	6 5				1 DH Ghost	
	D.H. 112	Sea Venom Mk. 21	AW F't'r.	2	0	42 8	36 6	8 5				1 DH Ghost	
	D.H. 110		AW F't'r.	2	0	51 0	53 5	10 1				2 R-R Avon	
	D.H. 104	Dove	Trans.	2	8-11	57 0	39 3	13 3	335	5,678	8,800	2 DH Gipsy Queen 70 Mk. 2 6r 380 hp.	200
	D.H. 114	Heron	Trans.	2	14-17	71 5	48 5	15 6	499	8,484	13,500	4 DH Gipsy Queen 30 Mk. 2 6r 250 hp.	191
	D.H. 106	Comet 2	Mil. Trans.	5		115 0	96 0	28 5	2,036	54,700	120,000	4 R-R Avon 6r 7,350 lb. t.	480*
	D.H. 106	Comet 3	Trans.			115 0	111 5	28 5	2,121		150,000	4 R-R Avon 6r 10,000 lb. t.	
	D.H. 106	Comet 4	Trans.	5	60-76	115 0	111 5	28 5	2,121	70,400	152,500	4 R-R Avon 6r 10,500 lb. t.	500*
	D.H. 106	Comet 4A	Trans.	4	70-92	107 8	114 8	28 4	2,096	71,800	152,500	4 R-R Avon 6r 10,500 lb. t.	543*
English Electric Co., Ltd.	P. 1		Fighter	1	0							2 R-R Avon	M >1
		Canberra T. 4	Trainer			64	65 6	15 7				2 R-R Avon	
		Canberra P.R. 7	Photo Rec.	2	0	64	66 8	15 7				2 R-R Avon	
		Canberra P.R. 9	Photo Rec.	2	0	68	66 8	15 7				2 R-R Avon	
		Canberra B. 8	Bomber	2	0	64	65 6	15 7				2 R-R Avon	
Fairey Aviation Co., Ltd.		Gannet A.S. Mk. 4	ASW	3	0	54 3	43 0	13				1 A-S Double Mamba	
		Gannet Mk. 2	Trainer	4	0	54 3	43 0	13 7				1 A-S Double Mamba 100 6r 2,950 eshp.	
		Delta 2	Res.	1	0	26 8	51 7	11 0				1 R-R Avon	
Folland Aircraft, Ltd.	F. Mk. 1	Gnat	Inter.	1	0	22 1	22 8	7 7	137	3,967	6,191	1 Bris. Orpheus 2 1 6r 4,520 lb. t.	
Gloster Aircraft Co., Ltd.		Meteor F.R. 9	Fighter	1	0	37 1	43 5	13 0	350	10,768	15,660	2 R-R Derwent 8 6r 3,500 lb. t.	595
		Meteor P.R. 10	Photo		0	43 0	44 3					2 R-R Derwent 8 6r 3,500 lb. t.	575
		Javelin F.A.W. 1	AW F't'r.	2	0	52 0	57 0	16 3	920		27,000	2 A-S Sapphire	
Handley Page, Ltd.	H.P. 80	Victor B. 1	Bomber		0	110 0	114 9	26 8				4 A-S Sapphire	
	H.P.R. 3	Herald	Trans.	2	44	95 0	70 3	22 5	886	23,200	37,500	4 Alvis Leonides Major 6r 866 hp.	248
Hawker Aircraft, Ltd.	P. 1067	Hunter F. 4	Fighter	1	0	33 8	45 9	13 2	340			1 R-R Avon RA21 6r 8,000 lb. t.	
	P. 1067	Hunter F. 6	Fighter	1	0	33 8	45 9	13 2	340			1 R-R Avon RA28 6r 10,000 lb. t.	
	P. 1101	Hunter T. 7	Trainer	2	0	33 7	48 8	13 2	340			1 R-R RA 21 or 28	

* Cruising Speed

Abbreviations:

Al.	Alvis	**Br.**	Bristol	**Lyr.**	Lycoming
A-S	Armstrong Siddeley	**Con.**	Continental	**M >1**	Supersonic
ASW	Anti-submarine warfare	**DH**	de Havilland	**P&W**	Pratt & Whitney
AW	All-weather	**eshp.**	Equivalent shaft horsepower	**R-R**	Rolls-Royce
Bl.	Blackburn	**hp.**	Horsepower	**Sven.**	Svenska Flygmotor
		lb. t.	Pounds thrust	**Wr.**	Wright

Manufacturer	Model designation	Aircraft name	Primary mission	Max. No. of crew	Max. No. of passengers	Overall wingspan, ft.	Overall length, ft.	Maximum height, ft.	Wing gross area, sq. ft.	Weight empty, lb.	Gross weight, lb.	Number, make, model and max. rating of powerplants	Max. speed, mph.
Hunting Percival Aircraft, Ltd.	.....	President	Transport	2	12	64.5	46.0	16.0	400	.....	13,500	2 Alvis Leonides @ 540 hp.	...
	.....	Pembroke	Multi	2	10	64.5	46.0	16.0	400	.....	13,000	2 Alvis Leonides @ 550 hp.	220
	.....	Provost T. Mk. 1	Trainer	2	0	35.2	28.8	12.2	214	.....	4,400	1 Alvis Leonides @ 550 hp.	201
	.....	Jet Provost T. Mk. 1	Trainer	2	0	35.6	31.9	12.8	214	.....	6,750	1 A-S Viper @ 1,750 hp.	324
A. V. Roe & Co., Ltd.	696	Shackleton M.R. 3	ASW	10	0	120.5	87.3	23.3	.....	.....	.....	4 R-R Griffon	...
	698	Vulcan B. 1	Bomber	...	.....	99.0	97.0	26.5	.....	.....	.....	4 Br. Olympus	...
Scottish Aviation, Ltd.	.....	Pioneer CC Mk. 1	Comm.	1	4	49.8	34.4	10.4	390	3,993	5,800	1 Alvis Leonides 502/7 @ 540 hp.	160
	.....	Twin Pioneer	Transport	1	16	76.5	45.3	12.3	670	8,732	13,500	2 Alvis Leonides 503 @ 540 hp.	180
Short Bros. & Harland, Ltd.	S.B. 5	.....	Research	1	0	30.5	45.8	.....	.....	.....	.....	1 R-R Derwent	...
	S.B. 6	Seamew A.S. 1	ASW	3	0	55.0	41.0	18.8	585	9,500	14,400	1 A-S Mamba	235
	Sc. 1	.....	Res. VTOL	...	.....	.....	.....	.....	.....	.....	.....	5 R-R RB108	...
Vickers-Armstrongs Ltd.	700 D	Viscount	Transport	2	40-53	93.7	81.8	26.8	963	37,200	57,000	4 R-R Dart 6 @ 1,740 eshp.	330
	800	Viscount	Transport	3	44-70	93.7	85.7	26.8	963	39,900	60,750	4 R-R Dart 6 @ 1,740 eshp.	335
	810	Viscount	Transport	2	44-65	93.7	85.7	26.8	963	40,540	63,750	4 R-R Dart 7 @ 1,990 eshp	425
	840	Viscount	Transport	2	44-65	93.7	85.7	26.8	963	41,130	64,500	4 R-R Dart 11 @ 2,080 eshp.	425
	950	Vanguard	Transport	3	76-139	118.5	122.3	34.9	1,829	72,000	127,500	4 R-R Tyne @ 5,315 eshp.	450
	N. 113	.....	Fighter	1	.....	37.2	55.3	15.0	.....	.....	.....	2 R-R Avon	...
	Valiant	Valiant	Bomber	5	.....	114.0	108.3	34.2	.....	.....	.....	4 R-R Avon	...
Westland Aircraft, Ltd.	W. 35	Wyvern S. 4	Strike	1	.....	44.0	42.0	15.0	355	15,608	21,200	1 A-S Python 3 @ 4,110 eshp.	383
HOLLAND													
Royal Dutch Aircraft Factories (Fokker)	S. 11	Instructor	Trainer	2	0	36.1	27.0	7.9	199	1,785	2,425	1 Lyc. O435-A @ 190 hp.	130
	S. 14	Mach Trainer	Trainer	2	0	39.5	43.7	15.3	342	8,300	11,800	1 R-R Derwent 8 @ 3,470 lb. t.	455
	S. 14-2	Mach Trainer	Trainer	2	0	39.5	43.7	15.3	342	.....	12,350	1 R-R Nene 2 @ 5,100 lb. t.	530
	F. 27	Friendship	Transport	3	36	95.0	73.0	26.5	754	20,610	34,200	2 R-R Dart @ 1,680 eshp.	280
ITALY													
S. A. I. Ambrosini	S. 7	Superactte	Personal	2	0	28.8	28.8	9.2	138	2,365	3,050	1 Alfa Romeo 115 @ 230 hp.	173
	F. 7	Rondone	Personal	2	2	30.5	22.3	9.2	114	1,056	1,694	1 Con. C90 @ 90 hp. or 1 Lycoming O-290-D2 @ 135 hp.	150 165
Industrie Meccaniche Aeronautiche Meridionali—AERFER	.....	A.S. Sagittario II	Fighter	1	0	24.6	31.2	6.6	158	4,960	7,160	1 R-R Derwent 9 @ 3,600 lb. t.	620
Fiat—Stabilimento Volivoli	G. 82-3B	.....	Trainer	2	0	36.1	42.4	13.3	271	9,500	12,900	1 DH Goblin 35 @ 3,500 lb. t.	515
	G. 91	.....	Fighter	1	0	.....	.....	.....	.....	.....	.....	1 Br. Orpheus	...
	G. 91 T	.....	Trainer	2	0	.....	.....	.....	.....	.....	.....	1 Br. Orpheus 4	...
	G. 91 R	.....	Photo Rec.	1	0	.....	.....	.....	.....	.....	.....	1 Br. Orpheus 3	...
	F. 86 K	.....	Fighter	1	0	37.2	40.9	15.0	288	.....	18,000	1 GE 7E-TG-190-D17 @ 7,350 lb. t. w/a	650
	Vampire Mk. 52	.....	Fighter	1	0	38.0	30.8	6.2	270	6,835	10,650	1 DH Goblin 3 @ 3,300 lb. t.	480
Aeronautica Macchi	M.B. 308	.....	Personal	2	0	32.8	21.4	7.1	148	915	1,433	1 Con. C85 @ 85 hp.	118
	M. B. 320	.....	Personal	1	5	42.6	28.4	10.5	227	3,284	4,960	2 Con. E185 @ 185 hp.	200
	M. B. 323	.....	Trainer	1	0	39.5	30.0	13.3	216	4,245	5,500	1 P&W R1340-81H1 @ 610 hp.	236
	M.B. 326	.....	Trainer	2	0	31.5	33.0	5.3	197	3,803	6,371	1 A-S Viper ASV5 @ 1,640 lb. t.	449
Nardi Soc. A. per Costruzioni Aeronautiche	F. N. 333	.....	Personal	1	3	32.7	23.0	8.8	155	1,635	2,980	1 Con. O470-B @ 240 hp.	180
Piaggio & Co. s. p. a.	P. 136-L	.....	Personal	1	4	44.4	35.4	12.6	270	4,430	6,400	2 Lyc. GO-480-B @ 275 hp.	182
	P. 148	.....	Trainer	2	0	36.5	27.7	7.9	203	1,931	2,645	1 Lyc. O-435-A @ 190 hp.	145
	P. 149	.....	Personal	1	3	36.5	28.1	9.5	203	2,560	3,700	1 Lyc. GO-480-B @ 275 hp.	187
	P. 150	.....	Trainer	2	0	42.3	30.8	9.2	271	4,365	5,600	1 P&W R1340-83H1 @ 600 hp.	236
SWEDEN													
Svenska Aeroplan A. B.	Saab-29	J-29	Fighter	1	0	36.1	33.2	12.3	258	9,480	13,360	1 Sven. RM-2 @ &,000 lb. t.	660
	Saab-32A	Lansen	AW Attack	2	0	42.7	48.1	15.7	.....	15,500	22,000	1 Sven. RM-5 @ 9,500 lb. t.	700
	Saab-90A-2	Scandia	Transport	3	40	91.9	69.9	23.3	922	21,960	35,270	2 P&W R2180-E1 @ 1,800 hp.	277
	Saab-91B	Safir	Trainer	3	0	34.8	26.0	7.2	146	1,580	2,315	1 Lyc. O435-A @ 190 hp.	170
	Saab-91C	Safir	Personal	1	3	34.8	26.0	7.2	146	1,625	2,685	1 Lyc. O435-A @ 190 hp.	169
	Saab-210	Draken	Research	1	0	.....	.....	.....	.....	.....	.....	1 A-S Adder @ 1,050 lb. t.	...
	Saab-35	Draken	AW Fighter	1	0	50	35	.....	.....	.....	.....	1 Sven. RM-6	M>1
	Saab-J32B	Lansen	AW Int.	2	0	42.7	48.0	15.5	.....	.....	.....	1 R-R Avon w/a	...
	Saab-J29F	.....	Fighter	1	0	36.1	33.2	12.3	258	.....	.....	1 Sven. RM-2 w/a @ 6,175 lb. t.	...

Abbreviations:

A-S — Armstrong Siddeley
ASW — Anti-submarine welfare
AW — All-weather
Br. — Bristol
Con. — Continental
DH — de Havilland
eshp. — Equivalent shaft hp.
hp. — Horsepower
lb. t. — Pounds thrust
Lyc. — Lycoming
M>1 — Supersonic
P&W — Pratt & Whitney
R-R — Rolls-Royce
Sven. — Svenska Flygmotor

Leading Foreign Aircraft, Military and Civil

GERMANY														
Aero-Flugzeugbau Hubert Zuerl	Aero-Jodel D11A	Club	Personal	1	1	26 9	20 3	6 7	137	735	1,224	1 Con A 65 66 65 hp		109
	Aero-Jodel D11B	Club	Business	1	1	26 9	20 3	6 7	137			1 Walter Mikron 66 65 hp		
	Aero-Jodel D11C	Club	Business	1	1	26 9	20 3	6 7	137			1 Con C 90-12F 66 90 hp		
	Aero-Jodel D-9	Aero-Bebe	Personal	1	0	23 0	17 5		97	386	662	1 Porsche 66 15 hp		93
Prof. Dipl. Ing. W. Blume Ingenieur-Buro fur Leichtbau und Stromungstechnik	Blume Bl 502		Personal	1	3	34 4	26 7	7 9	161	1,370	2,340	1 Lycoming O-320 66 150 hp		153
Dornier-Werke GmbH.	DO 27		Rec	1-2	3-4	39 5	31 5	8 9	209	2,000	3,300	1 Lycoming GO-480-B1A6 66 270 hp		161
Arbeitsgemeinschaft Klemm-Bolkow	KL-107		Personal	1	2	35 6	27 2	6 9	157	1,323	1,900	1 Con C 90-12 F 66 95 hp		
JAPAN														
Fuji Heavy Industries Ltd.	T-34A	Mentor	Trainer	2	0	32 9	25 9	9 5	178	2,170	2,900	1 Con O-470-13 66 225 hp		189
	LM-1	Nikko	Multi	1	3-4	32 9	25 9	9 5	178	2,080	3,245	1 Con O-470-13A 66 225 hp		185
	L-19		Rec	1	1	36 0	24 9	7 5		1,498	2,200	1 Continental 66 213 hp		130
SPAIN														
Aeronautica Industrial, S.A.	XL-10	AVD 12	Liaison	1	2	36 2	25 4	6 9	194	1,587	2,315	1 ENMASA Tigre G1V-B 66 150 hp		
	XL-10C	AVD 12	Liaison	1	3	36 2	25 4	6 9	194	1,775	2,822	1 Con O-470-A 66 225 hp		
	L-8C	I-11B	Trainer	2	0	30 5	20 1	6 2	144	928	1,430	1 Con C-90-12F 66 95 hp		
	E-6	I-115	Trainer	2	0	31 3	24 1	9 0	151	1,499	2,183	1 ENMASA Tigre G1V-B 66 150 hp		
Construcciones Aeronauticas, S.A.	E. 3	Bucker	Trainer											
	T. 8	Heinkel	Bomber											
	T. 7	Azor	Trans.	4	30-40	91 2	68 4	25 4	925	21,650	33,100	2 Bristol Hercules 730 66 2,040 hp		280
	T. 6	Halcon	Trans.	4	14-18	70 6	52 5	19 9	617	11,615	17,090	2 ENMASA Beta B-4 90-29-750 66 765 hp		230
	T. 5	Alcotan	Trans.	3	8-10	60 3	45 6	12 7	450	8,625	12,125	2 A-S Cheetah 27 66 475 hp		195
La Hispano Aviacion, S.A.	HA-1109M-1-L	Buchon	Fighter	1	0	32 5	29 5	8 5		5,390	6,500	1 R-R Merlin 500-45 66 1,600 hp		414
	HA-100-E1	Triana	Trainer	2	0	34 1	27 8	11 0	187	4,343	6,459	1 ENMASA Beta 66 755 hp		276
	HA-200-R1	Saeta	Trainer	2	0	34 2	29 1	10 7	187	3,697	7,000	2 Turbomeca Marboré IIA 66 880 lb t		435

Leading Foreign Rotary-Wing Aircraft

			Basic Data				Dimensions			Weights		Powerplant	Performance						Remarks
GREAT BRITAIN																			
Bristol Aeroplane Co., Ltd. *Filton, Bristol*	171 Mk. 4	Sycamore	5	48 6	61 40	10 1				4,150	5,600	1 Al Leonides 524 1 66 520 hp	89	127	1,300	8,400	15,500	398	
	173 Mk. 3		16	48 6	89 75	17 0				9,714	13,400	2 Al Leonides Major 66 1,740 hp	200	127	1,400	10,000	16,000	348	Development for MoS military copter
	192		27	48 8	89 15	17 0				9,846	18,000	2 Napier Gazelles 66 1,300 eshp	560	138	1,175	8,000	13,250	450	
Fairey Aviation Co., Ltd. *Hayes, Middlesex*		Rotodyne	46	90 0		22 2				39,000		2 Napier Eland 66 3,000 eshp and 4 Fairey Tip Pressure Jets		190	1,670			520	Two prototypes bought by MoS
		Jet Gyrodyne	4	60 0								1 Alvis Leonides 66 525 hp and 2 Fairey Pressure Jets (Rotor Tip)							Rotor head is similar to Rotodyne
		Ultra Light Helicopter	2	28 0		8 2				1,000		1 Blackburn Palouste 66 260 ghp and 2 Fairey Pressure Jets (Rotor Tip)		105	1,300	10,000	9 4	150	A.O.P. and reconnaissance, communications and transport
Saunders-Roe, Ltd. *Osborne, E. Cowes*		Skeeter Mk. 6	2	32 0	31 0	10' 2"				1,926	2,150	1 DH Gipsy Major 200 66 200 hp	23	101	1,020	4,100	11,900	237	Training and liaison duties
Westland Aircraft, Ltd. *Yeovil, Somerset*	W.-S.-51	Dragonfly	4-5	49 0		13 0				4,235	5,700	1 Al Leonides 66 525 hp	70		750			220	Sikorsky license
	W.-S.-55	Whirlwind	8-10	53 0		13 3				4,990	7,500	1 P&W R1340-40 66 600 hp	145	111	910	7,800		430	Sikorsky license
		Widgeon	9-12	49 2	57 3	12 9				4,322	5,900	1 Al Leonides 66 515 hp	83	95	700	7,800	10,000	300	
FRANCE																			
Sud-Est Aviation *Paris*	S.E.3120	Alouette	2	38 3	34 6	9 6				1,650	2,750	1 Salmson 9NH 66 200 hp	32	78	885				
	S.E.3130	Alouette II	5	38 5	31 8	9 0				1,810	3,300	1 Turbomeca Artouste II 66 400 hp	152	106	880	3,300	9,500	346	
Ouest Aviation *Paris*	S.O.1110	Ariel 3	3	35 4	24 6					1,496	2,750	1 Turbomeca 66 275 eshp		102		5,900		155	
	S.O.1221	Djinn	2	32 8	17 4	9 6				682	1,540	1 Turb. Palouste 66 528 eshp		82		3,280		310	
	S.O.1310	Farfadet	4	36 7								1 Turb. Artouste 2 66 360 eshp		150				240	
NETHERLANDS																			
Nederlandse Helicopter Industrie N. V., *Rotterdam*	H-3	Kohlerc	2	32 8	32 8	8 4				1,322	1,874	1 N.H.I. TJ-5 66 60 hp		65	800				
SPAIN																			
Aerotecnica, S. A.	AC-12		2	28 0	27 2	9 0				1,058	1,553	1 Lyc. O-320 66 150 shp	26 4	75	850	5,800	13,000	195	
	AC-13		3	29 7	25 6	9 0				1,208	1,962	1 Turb. Artouste I 66 280 hp	31 7	93	984	8,700	19,900	125	
	AC-14		5	31 5	33 5	9 5				1,562	2,645	1 Turb. Artouste II 66 400 hp	79 3	124	1,575	12,140	30,860	600	

Abbreviations:
Al. Alvis.
A.O.P. Air Observation Post.
Bl. Blackburn.
DH De Havilland.
Lyc. Lycoming.
MoS Ministry of Supply.
P&W Pratt & Whitney Aircraft.
Turb Turbomeca.

● SPECIFICATIONS

Leading Foreign Gas Turbines

Manufacturer	Basic Data					Performance			Physical Data			Remarks
	Model designation	Type	No. of compressor stages	No. of turbine stages	No. of combustors	Max. power at S.L.	Specific fuel consumption at max. power, lb./hr./lb.	Compression ratio at max. power	Overall length, in.	Overall diameter, in.	Dry weight, lbs.	
CANADA												
Orenda Engines, Ltd. *Malton, Ont.*	Orenda 10	AFJ	10	1	6	6,355 lb. t.	1.12	5.3	42	123	2,515	
	Orenda 11	AFJ	10	2	6	7,000 lb. t.	.....	.....	45	121	2,405	
	Orenda 14	AFJ	10	2	6	7,275 lb. t.	.....	.....	45	121	2,425	
	Iroquois PS-13	AFJ	.....	.....	.....	20,000 lb. t.	.....	.....	.....	.....	.....	30,000 lb. t. w/afterburner
GREAT BRITAIN												
Armstrong-Siddeley Motors, Ltd. *Parkside, Coventry*	Mamba ASM. 6	AFP	11	3	A	1,650 eph.	.715	5.84	34	61	1,003	Mark 110: also ASM. 8
	Double Mamba ASMD. 3	AFP	10	3	A	2,090 eph	.754	5.35	53	99	2,406	Also ASMD. 8
	Viper ASV. 5	AFJ	7	1	A	1,640 lb. t.	1.11	3.5	24	66	510	
	Viper ASV. 8	AFJ	7	1	A	1,750 lb. t.	1.11	4.0	24	66	510	
	Viper ASV. 9	AFJ	7	1	A	1,900 lb. t.	1.14	.....	24	66	525	Uprated ASV. 8
	Viper ASV. 10	AFJ	.....	.....	A	2,000 lb. t.	1.01	.....	28	66	570	
	Viper ASV.11	AFJ	7	1	A	2,460 lb. t.	1.11	.....	24	68	570	Uprated ASV. 10
	Sapphire ASSa. 6	AFJ	13	2	A	8,200 lb. t.	0.85	7.5	37	110	2,670	
	Sapphire ASSa. 6R	AFJ	13	2	A	10,000 lb. t.	1.76	.....	37	110	2,608	Afterburner version
	Sapphire ASSa. 7	AFJ	13	2	A	11,000 lb. t.	0.88	7.3	37	108	3,075	Also ASSa. 5&8
Bristol Aero-Engines, Ltd. *Filton, Bristol*	Proteus 755	ACFP	12A, 1C	4	8	4,120 eshp.	0.445	7.2	40	100	2,850	In production
	Olympus 101	AFJ	.....	.....	A	11,000 lb. t.	.....	.....	40	128	3,650	
	Olympus 102	AFJ	.....	.....	A	12,000 lb. t.	.....	.....	42	132	.....	
	Olympus B. O1.6	AFJ	.....	.....	A	16,000 lb. t.	.....	.....	41	152	.....	
	Orpheus B.Or.2	AFJ	.....	.....	A	4,520 lb. t.	.....	.....	32	73	.....	For Folland Gnat
	Orpheus B.Or.3	AFJ	.....	.....	A	4,850 lb. t.	.....	.....	32	74	.....	For Fiat G-91, Dassault Etendard 6, Breguet Taon
	Orion B. On.1	AFP	7A, 5A	1, 3	A	5,150 eshp.	0.84	10	42	112	3,150	sfc. = .395 at altitude
De Havilland Engine Co., Ltd. *Edgware, Middlesex*	Goblin 35	CFJ	1	1	16	3,500 lb. t.	1.16	3.7	50	101	1,630	
	Ghost 103	CFJ	1	1	10	4,850 lb. t.	1.15	4.5	53	123	1,925	
	Ghost 105	CFJ	1	1	10	5,350 lb. t.	1.19	4.7	53	129	1,935	
	Gyron	AFJ	.....	.....	.....	15,000 lb. t.	.....	.....	46	154	.....	
	Gyron Jr. DGJ.1	AFJ	.....	.....	.....	.....	.....	.....	32	113	.....	Scaled-down Gyron
D. Napier & Son, Ltd. *London, W. 3*	Eland N.E1.1	AFP	10	3	6	3,000 eshp.	0.64	7.0	36	120	1,575	
	Eland N.E1.3	AFP/G	10/9	3	6	3,000 eshp.	0.62	7.0	36	158	2,350	
	Eland N.E1.4	AFP	10	3	6	4,000 esph.	0.56	7.0	36	122	1,800	
	Eland N.E1.5	AFP	10	3	6	4,200 eshp.	0.56	8.0	36	122	1,800	
	Eland N.E1.6	AFP	10	3	6	3,500 eshp.	0.69	7.0	36	122	1,735	
	Oryx N.Or.1	AFG	12/4	2	8	750 ghp.	0.68	6.0	19	83	495	
	Oryx N.Or.4	AFG	12/4	2	8	825 ghp.	0.66	6.0	19	83	495	
	Oryx N.Or.5	AFG	12/4	2	8	950 ghp.	0.62	6.1	19	83	515	
	Gazelle N. Ga.1	AFP	.....	.....	.....	1,250 shp.	.....	.....	.....	.....	.....	Free turbine engine
Rolls-Royce, Ltd. *Derby*	Avon R.A.7	AFJ	12	2	8	7,500 lb. t.	0.92	6.5	42	102	2,450	
	Avon R.A.7R	AFJ	12	2	8	9,500 lb. t.	1.00	6.5	42	120	2,960	Afterburner version
	Avon R.A.21	AFJ	12	2	8	8,000 lb. t.	0.93	6.4	42	102	2,520	
	Avon R.A.14	AFJ	.....	.....	A	9,500 lb. t.	0.84	.....	42	113	2,860	
	Avon R.A.26	AFJ	.....	.....	A	10,000 lb. t.	0.86	.....	42	113	2,790	
	Avon R.A.28	AFJ	.....	.....	A	10,000 lb. t.	0.86	.....	42	113	2,890	
	Avon R.A.24 & 24R	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	Development engines
	Nene Mk. 10	CFJ	1	1	9	5,100 lb. t.	1.06	4.45	50	105	1,620	
	Nene Mk. 101	CFJ	1	1	9	5,000 lb. t.	1.09	4.45	50	78	1,618	
	Nene Mk.3 & 102	CFJ	1	1	9	5,100 lb. t.	1.06	4.45	50	97	1,620	
	Nene Mk. 103	CFJ	1	1	9	5,400 lb. t.	1.07	4.45	50	78	1,612	
	Soar R.Sr. 2	AFJ	.....	.....	A	1,860 lb. t.	1.27	.....	16	59	275	
	Conway R.Co.5	BPJ	.....	.....	A	13,000 lb. t.	.....	.....	42	129	.....	
	Conway R.Co.7	BPJ	.....	.....	A	13,007 lb. t.	.....	.....	42	129	.....	Also R.Co. 8&10
	Dart Mk.505	CFP	2	2	7	1,540 ehp.	0.753	5.5	38	95	1,030	Mk. 509, sfc-.727
	Dart Mk.510	CFP	2	2	7	1,740 eph.	0.689	5.5	38	98	1,110	
	Dart Mk.511	CFP	2	2	7	1,720 ehp.	0.698	5.5	38	98	1,195	
	Dart Mk.520	CFP	2	3	7	1,890 ehp.	0.700	5.8	38	98	1,250	
	Dart Mk.525	CFP	2	3	7	1,990 ehp.	0.68	5.8	38	98	1,250	
	Dart R.Da.7/2	CFP	2	3	7	2,105 ehp.	0.665	5.8	38	98	1,250	
	Dart R.Da.10	CFP	2	3	7	2,655 ehp.	0.640	.....	.....	.....	.....	
	Tyne R.Ty.1	AFP	.....	.....	.....	4,695 ehp.	0.405	13.0	41	100	2,023	
FRANCE												
Generale Aeronautique Marcel Dassault *St. Cloud (S. & O.)*	M.D.30 Viper	AFJ	7	1	A	1,630 lb. t.	1.10	3.8	27	66	496	Armstrong-Siddeley license
	M.D. 30R	AFJ	7	1	A	2,205 lb. t.	2.30	3.8	27	132	761	M.D.30 w/afterburner
	R.7	AFJ	7	1	A	3,085 lb. t.	1.07	3.8	29	79	748	
Societe d'Exploitation des Materiels Hispano-Suiza *Bois-Colombes (Seine)*	Tay 250A	CFJ	1	1	9	5,066 lb. t.	1.06	4.0	50	100	1,973	Rolls-Royce license
	Verdon R-450	CFJ	1	1	9	7,700 lb. t.	.....	.....	49	103	2,057	
Societe Nationale d'Etude et de Construction de Moteurs d' Aviation *Paris*	Atar 101D	AFJ	7	1	A	6,600 lb. t.	1.03	4.5	36	141	1,895	
	Atar 101E	AFJ	8	1	A	7,715 lb. t.	0.99	4.8	36	162	1,851	
	Atar 101G	AFJ	8	1	A	9,700 lb. t.	1.85	4.8	36	255	2,735	101E w/afterburner
	Atar 8	AFJ	9	.....	.....	9,240 lb. t.	.....	.....	.....	.....	.....	Atar 9 has afterburner
	Vesta	AFJ	9	1	A	3,085 lb. t.	.....	.....	27	79	640	
Societe Turbomeca *Paris*	Palas	CFJ	1	1	A	352 lb. t.	1.17	3.95	16	47	158	
	Marbore 2	CFJ	1	1	A	880 lb. t.	1.15	3.85	25	62	314	
	Marbore 4	CFJ	1	1	A	1,000 lb. t.	1.20	3.5	25	62	300	
	Arbison	.....	.....	2	A	552 lb. t.	0.90	5.5	21	57	236	
	Gourdon	ACFJ	2	2	A	1,545 lb. t.	1.00	5.0	24	75	396	
	Gabizo	ACFJ	2	1	A	2,400 lb. t.	1.04	5.2	21	82	585	
	Soulor	ACFJ	2	2	A	704 lb. t.	0.8	5.0	18	59	354	
	Artouste 2	CFP	1	2	A	396 eshp.	1.07	3.6	23	67	288	
	Artouste 3	ACFP	2	3	A	594 eshp.	0.65	5.5	21	58	318	
	Bastan	ACFP	2	3	A	741 eshp.	0.67	5.2	21	61	396	
	Marcadau	CFP	1	2	A	396 eshp.	1.07	3.6	22	57	350	
	Palouste 4	CFJ	1	2	A	2.52 lb./sec	.....	3.8	22	53	200	Fuel flow: 260 lb./hr.
	Autan 2	ACFP	2	3	A	3.0 lb/sec	.....	5.1	21	54	250	Fuel flow: 350 lb./hr.
	Turmo 2	CFP	1	2	A	396 eshp.	1.07	3.9	26	49	320	
	Turmo 3	CFP	1	3	A	786 eshp.	0.72	5.5	31	66	530	
ITALY												
FIAT-SMA *Turin*	4002	CFJ	1	1	A	550 lb. t.	1.25	4.0	22	41	220	

Abbreviations

A — annular
ACFJ — axial-centrifugal turbojet
ACFP — axial-centrifugal turboprop
AFJ — axial-flow turbojet
AFG — axial-flow gas generator
AFP — axial-flow turboprop
BPJ — bypass jet
CFJ — centrifugal-flow turbojet
CFP — centrifugal-flow turboprop
eshp. — equivalent shaft horsepower
ghp. — gas horsepower
lb. t. — pounds of thrust

Supermarket
for
precision components

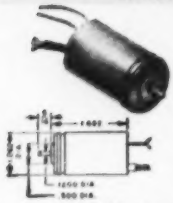
- ROTATING COMPONENTS
- RADAR ANTENNA DEVICES
- GYROS . . . . . .
- COMPONENT PACKAGING

ECLIPSE-PIONEER DIVISION, BENDIX AVIATION CORPORATION
TETERBORO, N.J.

PRINTED IN U.S.A.

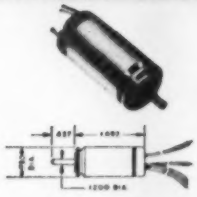
Publication No. 5612-13
Supersedes Publication No. 563-1

AY-190 SERIES, SIZE 11 FRAME — AUTOSYN® SYNCHROS — AY-300 SERIES, SIZE 8 FRAME



Function	Corrosion Resistant
Transmitter	AY-190-A1
Control Transformer	AY-191-A1
Resolver	AY-192-A1
Differential	AY-193-A1
Receiver	AY-194-A1*

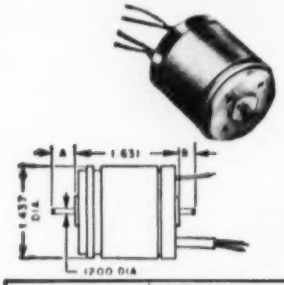
* Receiver not normally furnished in corrosion resistant construction.



Function	Corrosion Resistant
Receiver	AY-300-2-A1*
Control Transformer	AY-300-25-A1
Transmitter	AY-300-26-A1
Control Transformer (HI-Z)	AY-300-38-A1
Resolver	AY-320-25-A1
Differential	AY-330-25-A1

* Receiver not normally furnished in corrosion resistant construction

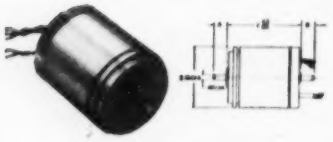
AY-200 SERIES AUTOSYN SYNCHROS — SIZE 15 FRAME



TYPICAL No.	Dimension A	Dimension B
AY-200-1	¼	0
AY-201-1	½	0
AY-202-1	7/16	⅜

FUNCTION	STANDARD CONSTRUCTION	CORROSION RESISTANT	HIGH TEMPERATURE
Multi-Power Transmitter	AY-20 ☐S-1-B	AY-20 ☐S-44-B	
Receiver	AY-20 ☐S-2-B		
Control Transformer	AY-20 ☐S-3-B	AY-20 ☐S-25-B	
Single-Power Transmitter	AY-20 ☐S-4-B	AY-20 ☐S-26-B	AY-20 ☐S-31-B
Control Transformer (HI-Z)	AY-20 ☐S-5-B	AY-20 ☐S-38-B	
Linear		AY-21 ☐S-42-B	AY-21 ☐S-48-B
Resolver (HI-Z)	AY-22 ☐S-5-B	AY-22 ☐S-38-B	
Resolver	AY-22 ☐S-27-B	AY-22 ☐S-25-B	
Differential (Servo Application)	AY-23 ☐S-3-B	AY-23 ☐S-25-B	
Differential (Synchronous Application)	AY-23 ☐S-4-B		
Resolver (Omni Application)	AY-24 ☐S-5-B		
Resolver (HI-Frequency)	AY-25 ☐S-24-B	AY-25 ☐S-39-B	
Resolver, Control Transformer	AY-26 ☐S-3-B		
Variable Transformer	AY-27 ☐S-43-B	AY-27 ☐S-46-B	AY-27 ☐S-46-B

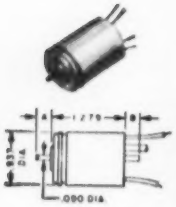
AY-400 SERIES AUTOSYN SYNCHROS — SIZE 22 FRAME



TYPE No.	Dimension A	Dimension B
AY-401-1	½	0
AY-402-1	½	½

FUNCTION	STANDARD CONSTRUCTION	CORROSION RESISTANT
Transmitter	AY-40 ☐-1-A	AY-40 ☐-2-A
Differential	AY-43 ☐-1-A	AY-43 ☐-2-A

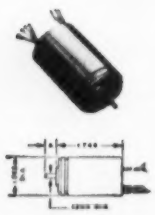
AY-500 SERIES "PYGMY" AUTOSYNS — SIZE 10 FRAME



TYPICAL No.	Dimension A	Dimension B
AY-500-2	¼	0
AY-502-2	⅛	⅛
AY-503-2	⅜	0

FUNCTION	STANDARD CONSTRUCTION	CORROSION RESISTANT	HIGH TEMPERATURE
Receiver	AY-50 ☐-2-A1		
Control Transformer	AY-50 ☐-3-A1	AY-50 ☐-25-A1	
Transmitter	AY-50 ☐-4-A1	AY-50 ☐-26-A1	AY-50 ☐-8-A1
Control Transformer (HI-Z)	AY-50 ☐-5-A1	AY-50 ☐-38-A1	
Linear	AY-51 ☐-10-A1		
Resolver	AY-52 ☐-3-A1	AY-52 ☐-25-A1	
Differential	AY-53 ☐-3-A1	AY-53 ☐-25-A1	
Resolver (HI-Z)	AY-54 ☐-5-A1	AY-54 ☐-38-A1	
Resolver (HI-Frequency)	AY-55 ☐-24-A1	AY-55 ☐-39-A1	

AY-600 SERIES AUTOSYN SYNCHROS — SIZE 11 FRAME



TYPICAL No.	A INCHES
AY-600-1	9/16
AY-601-1	½

FUNCTION	STANDARD CONSTRUCTION	CORROSION RESISTANT	HIGH TEMP. AND CORROSION RESISTANT
Multi-Power Transmitter	AY-60 ☐-1-A1	AY-60 ☐-6-A1	
Control Transformer	AY-60 ☐-3-A1	AY-60 ☐-5-A1	AY-60 ☐-12-A1
Control Transformer (Med. Z)		AY-60 ☐-11-A1	AY-60 ☐-9-A1
Receiver	AY-60 ☐-10-A1		
Single-Power Transmitter	AY-60 ☐-8-A1		
Resolver	AY-62 ☐-3-A1	AY-62 ☐-5-A1	
Differential		AY-63 ☐-5-A1	AY-63 ☐-12-A1

Units listed have loose leads. Can also be furnished with terminal boards.

LOW INERTIA SERVO MOTORS

TYPE No.	RATED VOLTAGE Phase 1	Phase 2	Max. Power Input Total (Watts)	No Load Speed (RPM)	Stall Torque (Oz. in.)	Torque to Inertia Ratio (Radians-sec.^{2})	Frame Size	REMARKS
CK-1018-7-A1	18	18	5.0	10,000	0.13	18,400	10	Tapered Shaft
CK-1018-16-A1	26	26	6.0	10,000	0.3	40,000	10	125°C Ambient Temp. Corrosion Resistant, Tapered Shaft
CK-1025-13-A1	115	115 57.5	12.0	4,800	1.45	31,000	15	MK 7 Mod. 1
CK-1027-14-B1	115	115 57.5	7.0	6,200	0.60	41,500	11	
CK-1027-15-B1	115	180 90	7.2	6,200	0.60	41,500	11	
CK-1031-18-A1	26	55	9.0	6,175	0.35	10,000	10	Corrosion Resistant
CK-1038-17-A1	26	50	4.75	5,500	0.39	14,500	15	Pinion on Tapered Shaft
CK-1041-19-A1	26	65	6.6	3,600	0.7	3,500	15	Drag Cup
CK-1043-17-A1	26	50	4.75	5,500	0.39	14,500	15	Tapered Shaft
CK-1045-16-A1	26	26	6.0	10,000	0.3	40,000	10	125°C Ambient Temp. Corrosion Resistant, Splined Shaft
CK-1048-24-A1	18	18	3.0	6,300	0.15	21,300	8	Splined Shaft
CK-1048-29-A1	26	26	4.5	6,300	0.20	28,300	8	Splined Shaft
CK-1049-25-A1	26	26	6.5	5,800	0.35	19,000	8	Splined Shaft
CK-2006-5-A1	115	115	30.0	6,600	3.0	5,700	20	
CK-2006-13-A1	115	115	26.0	6,000	2.5	41,500	20	Corrosion Resistant
CK-2011-13-A1	115	115	26.0	6,000	2.5	41,500	20	Corrosion Resistant
CK-3004-4-A1	115	230	70.0	3,700	14.5	5,800	28	

RATE AND SERVO MOTOR GENERATORS

TYPE No.	RATED VOLTAGE Phase 1	Phase 2	Max. Power Input Total (Watts)	No Load Speed (RPM)	Stall Torque (Oz. in.)	Torque to Inertia Ratio (Radians-sec.^{2})	Gen. Excit. (Volts)	Generator Output (Volts)	Frame Size	REMARKS
FV-10 -5-A1	26	26	7.0	10,000	0.28	20,000	18	0.3 1000	10	Corrosion Resistant
FV-103-6-A1	115	115 57.5	7.0	6,200	0.60	25,500	115	0.5 1000	11	
FV-104-7-A1	26	26	9.7	6,000	0.50	22,000	26	0.5 1000	11	High Temperature Corrosion Resistant
FV-109-10-A1	26	26	7.0	10,000	0.28	14,000	18	0.3 1000	10	Includes Permanent Magnet Generator for Speed Measurement
FV-110-9-A1	26	52 26	7.0	10,000	0.28	20,000	26	0.5 1000	10	Corrosion Resistant
FV-110-12-A1	33	52	7.0	10,000	0.28	20,000	26	0.5 1000	10	Corrosion Resistant
FV-112-11-A1	18	18	3.0	6,300	0.15	13,000	18	0.25 1000	8	Corrosion Resistant
FV-2001-4-A1	115	115	23.0	7,200	2.5	69,000	18	0.3 1000	20	Corrosion Resistant
FV-2005-5-A1	115	115 57	26.0	6,000	2.5	39,000	115	0.5 1000	20	Corrosion Resistant
FV-2007-6-A1	115	115	25.0	7,000	2.8	5,400	18	0.3 1000	20	Corrosion Resistant
FV-3005-5-A1	115	230 115	70.0	3,700	14.5	4,200	115	0.5 1000	28	

RATE AND SERVO MOTORS — CENTER TAPPED CONTROL WINDINGS

TYPE NUMBER	FRAME SIZE	CONT. PHASE VOLT.	CENTER TAPPED CONTROL PHASE TOTAL Z	R	X	POWER CONT. PHASE	FIXED PHASE VOLT.	FIXED PHASE Z	R	X	POWER FIXED PHASE	EFFECTIVE RESISTANT CONTROL PHASE	TORQUE
1265271	8	55	750	597	450	3.19	26	170	142	93	3.25	960	.3
1265272	10	52	584	419	405	3.3	26	146	105	101	3.3	830	.3
1265273	11	40	263	151	215	3.5	115	2175	1250	1780	3.5	460	.63
1269605	8	26	290	240	158	2.2	26	290	240	158	2.2	310	.2
1269606	10	26	290	240	158	2.2	26	290	240	158	2.2	310	.2
FV100-12-A1	10	33	241	175	167	3.3	26	146	105	101	3.3	335	.3
1269702	8	52	680	568	372	3.25	26	170	142	93	3.25	830	.3

ORDNANCE AND NAVY TYPE AUTOSYN SYNCHROS

TYPE No. ECLIPSE-PIONEER	MILITARY	FUNCTION
AY-1601-5	15TR4A	Torque Receiver
AY-2400-9	23CX6	Control Transmitter
AY-2400-10	23CT6	Control Transformer
AY-2400-12	23TX6	Control Transmitter
AY-2400-13	23TR6	Torque Receiver
AY-2401-10	23CT6A	Control Transformer
AY-3200-9	31TX4A	Torque Transmitter
2323-1	1HCT	Control Transformer
2324-1	1HG	Transmitter
2325-1	1HDG	Differential Transmitter
2326-1	3HCT	Control Transformer
2327-1	3HG	Torque Transmitter

TYPE No. ECLIPSE-PIONEER	MILITARY	FUNCTION
2328-1	3F	Receiver
2330-1	1F	Receiver
2340-1	5HG	Transmitter
2341-1	5F	Receiver
2343-1	1D	Differential Receiver
2344-1	6HG	Transmitter
2345-1	3D	Differential Receiver
2346-1	5SCT	Control Transformer
2352-1	5HDG	Differential Transmitter
2353-1	5HCT	Control Transformer
2369-1	6HDG	Differential Transmitter

PRECISION GYROS FOR ALL APPLICATIONS

Eclipse-Pioneer . . . the nation's foremost supplier of panel indicator gyros . . . offers a complete line of gyros to meet all applications. This group includes all the basic vertical, rate, free, and directional gyro types used as reference components in complete navigation, radar, compass, autopilot, and guidance systems.

Type Number 14110-1-A

VERTICAL GYRO TRANSMITTERS

FEATURES: Includes quick erecting mechanism which makes the remote unit ready for operation within 3 minutes. • Two ball erection system • Non-tumbling stops • Inclined axis (1 degree) to minimize turn error.

Power requirement	115 volts, single phase, 400 cps	**Autosyn excitation**	26 volts, 400 cps
Starting	19 watts, 0.9 P.F.	**Erection rate (normal)**	3°/minute
Running	13 watts, 0.85 P.F.	**Weight**	2¾ lbs.
Gyro speed	22,000 rpm	**Size**	3⅛" diameter x 5 $^{13}/_{16}$" long
Gyro moment	600 gram cm^2		

Diameter — 6⅛" Weight — 6¼ lbs. Height — 6¾"

Designed for use as a remote vertical reference where vertical stabilization is required. The instrument is essentially an electrically driven, vertical-seeking gyro with separate Autosyn transmitter pick-offs on the pitch and bank axes. Provisions are incorporated to reduce bank error encountered in turns.

- **Operating temperature range:** −55°C to +70°C.
- **Operational limits:** 360° in roll and pitch with controlled tumbling of the pitch axis at near 90°.
- **Accuracy:** The erection system maintains the gyro in a vertical position to within ¼° of vertical position with respect to the earth.
- **Caging:** From any position at full rotor speed in less than 45 seconds.

Type Number 14104-1-B

This Vertical Gyro Transmitter provides roll and pitch displacement signals which will operate remote indicating devices or which can be used wherever attitude information could be applied. It consists of an electrically driven, torquer erected, vertical seeking gyro enclosed in a hermetically sealed case with separate Autosyn transmitter pick-offs on the roll and pitch axes.

Provisions have been made so that the pitch and roll erection systems can be cut out by external switches.

An outstanding feature of this instrument is the use of the newly developed Eclipse-Pioneer Electrolytic Switch which provides precise erection and has long serviceability. Besides being rugged, of simple design, and easily serviceable, the transmitter also features a quick erection to true vertical instead of vertical in relation to the instrument case; a sensitive measuring vertical detection system with an accuracy of better than ¼°; and an improved gimbal construction resulting in greater operational stability. This gyro is completely self-contained and requires no erection amplifier.

Type Number 14126-1-A

Size: 4¾" diameter, 8 $^{21}/_{32}$" in length
Weight: Approx. 6 lbs. without shockmount
Power requirements: Gyro Motor and Erection System — 115 volts, 400 cycles, 3 phase
Autosyn — 26 volts, 400 cycles, 1 phase

VERTICAL GYRO—Non pendulous

Momentum: 4,000,000 gm cm^2/sec

Freedom: 360° in roll. Controlled tumbling near ± 82° in pitch with stops set to provide minimum loop error at 10°/sec rate of loop

RADAR ANTENNA DEVICES

GROUND ANTENNA PEDESTAL TYPE NUMBER 40101-1-A

SPECIFICATIONS

Weight	700 lbs.
Data accuracy	0.5 Mil.
Slewing rates (in azimuth and elevation)	12 rpm.
Operating temperature range	−54°C to +66°C
Elevation and Azimuth Servo drives	Two-speed 60 cps synchro data systems are used, having ratios of 1:1 and 16:1
	¼ HP motors (DC) for use with an Amplidyne servo system
Wind loading	50 mph (full operating performance) 100 mph (no structural damage)

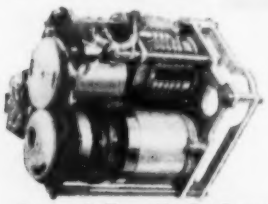
SPECIFICATIONS

Standard frequency range	9345 tto 9405 mc/s. This permits beacon operation at 9310 mc/s
Optional frequency range	9215 to 9275 mc/s
Operation	Up to 60KW peak with a 0.001 duty cycle
Beam width	4° maximum in E and H planes
Side lobes	At least 18 db below main lobe peak
Polarization	Horizontal
Weight	24 lbs. (approximate)
Operating temperature range*	−40°C to +55°C
Storage temperature range*	−65°C to +55°C
Humidity	10% to 95%

*These temperature ranges can be extended for specific applications.

AIRBORNE WEATHER RADAR ANTENNA TYPE NUMBER 40023-□-A

COMPONENT PACKAGING



Servo Follow-Up Package

External Slip Ring Autosyn

In addition to supplying catalog component items such as — synchros, motors, gyros, etc. — Eclipse-Pioneer is in an excellent position to offer a premium in the way of customer service and accommodation on component packaging.

We may have already solved a problem similar to yours, thus enabling our system specialists to adapt from our extensive line, existing production packages to meet your systems requirements.

Should your problem turn out to be entirely new, we can — and will — design, develop, and produce a component or complete system to solve your specific problem.

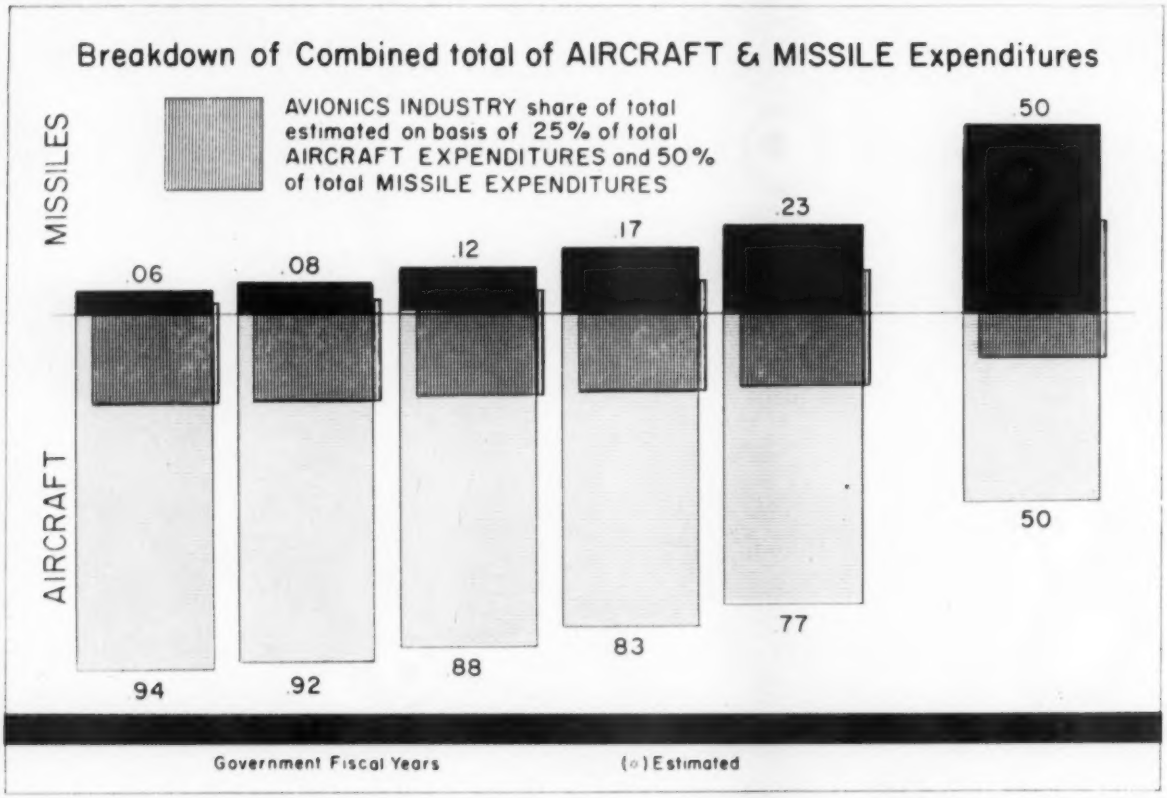
No package is too small or too large for Eclipse-Pioneer, and may be as simple as an Autosyn mounting clamp or be more complex such as a complete servo follow-up subassembly from a production computer.

ECLIPSE-PIONEER DIVISION

TETERBORO, NEW JERSEY

Bendix
AVIATION CORPORATION

AVIONICS



Missiles Mean Avionic Profit, Headache

By Philip J. Klass

Trend from piloted aircraft to missiles will bring the avionics industry more business, more headaches, changes in the way the business is done and new directions for technological efforts. For example:

• **More Business:** Avionics will get an increasing share of the defense budget because the avionic content of missiles averages about 40-50% of total weapon cost, roughly twice that of piloted aircraft.

• **More headaches:** Replacing and augmenting the human pilot with avionic black boxes will increase military demands for greater reliability, better performance, lower weight, smaller size.

• **New ways of doing business:** The avionics industry's single direct customer in the past—the Government—will become one of its smallest. More and more avionics equipment will be sold directly to weapon system prime contractors and in the case of missiles, some of these will be avionic manufacturers themselves.

• **Changing technological emphasis:** Emphasis will shift from development of radio for ground-air voice communication to its use for point to point communication, or for data transmission and remote control of pilotless aircraft and missiles. Need to make a missile invulnerable to enemy countermeasures will result in more emphasis on self-contained guidance systems, less on ground-based navigation systems.

Sponsorship Dilemma

One serious problem raised by the trend toward missiles is: who will sponsor state-of-the-art and system developments needed for future generations of missiles?

Some complex avionic systems, such as bombing-navigation and fire control, frequently require a longer gestation period than the airframe or powerplant with which they will be used.

Prior to the weapon system management plan, the military would launch specific equipment developments often before it was known on which airframe they would be used. Only by so doing could certain critical avionic systems be available when needed, although the result sometimes was ill-suited to the airplane which later evolved.

The weapon system management plan raised serious fears in the avionics industry, and in some military circles, that there was no provision for developing the techniques and systems which would be needed for future weapons. They reasoned that weapon system contractors would be able to sponsor only avionic system developments for their specific needs with the result that the technological well might soon run dry.

Weapon system management has not been in operation long enough to prove or disprove these fears. If they were justified in the past, there is even more cause for alarm. With the obvious trend toward missiles, every prime contractor operates on the weapon system management type plan of buying and specifying practically all the equipment that goes into his vehicle.

Military Financing?

It is doubtful whether any missile prime contractor will be given the authority to sponsor research and development programs which clearly have no application to his current project. It is equally doubtful whether military agencies will be able to sponsor devel-

opment of complete guidance or control systems with any assurance that the specific equipment will be selected by some as yet unselected prime contractor on a missile whose size and configuration is not even a gleam in a designer's eye.

The military can sponsor basic state-of-the-art research and development into guidance, control, and computing techniques, for instance. So it should also be possible to sponsor the development of major components and subsystems which can find wide application in a variety of missiles. Gyroscopes, stable platforms, infrared components, standardized radar intermediate frequency amplifiers are typical examples.

But it still requires a long time to design and produce a complex system, even when many of the necessary components and techniques are available.

Company Financing?

Solution to this problem may lie in avionic industry financed research and development, with military agencies like Bureau of Aeronautics and Wright Air Development Center, giving indirect guidance. Behind this approach is the idea that a company specializing, for example, in infrared components is possibly in the best position to know where the state-of-the-art needs advancement, based on the needs of its infrared guidance system and missile customers.

Older, larger avionics companies long have operated this way in their non-military business. The price of their non-military products includes funds for financing future company development and research efforts.

In the military field, avionic companies have trouble selling the same concept. The military believes that it should direct and control research and development to be sure it meets its end needs and to obtain patent rights to such developments. Weapon system management forced some modification of this philosophy. The trend to missiles may force a more drastic change.

Defense Department officials on many occasions have urged industry to supplement military research and development efforts with company funds. However, the profit level on military procurement does not provide much margin for financing company research.

Although the government will continue to sponsor basic research and development, the trend to missiles will make it more difficult to sponsor specific avionic development programs. This important area, between what might be termed the techniques and the ultimate hardware tailored to a specific missile, is one which the avionics industry may have to fill with company effort. However, the Government will have to find some indirect way to provide the financial resources needed for such work.

Speed and extent which guided missiles take over tactical responsibilities of piloted aircraft depends partly on the ingenuity of the avionics designer and manufacturer.

Despite remarkable strides during the past decade, the avionics industry still has a long way to go before it can match the versatile capabilities of the human pilot. For instance, avionic designers build 100-lb. autopilots that fly an airplane far more proficiently than the human pilot, make instrument approaches with greater precision and less strain.

But this 100 lb. autopilot performs only a small portion of the total job which the human pilot performs. The autopilot by itself can not distinguish between the Hudson river and the Delaware river for navigation purposes.

A 150-lb. Doppler radar automatic navigator can continuously determine an airplane's exact position far more accurately and dependably than a human pilot or navigator, but this is but a single function. The auto-navigator can not determine where to aim the airplane in order to shoot down an attacking bomber. That requires another piece of avionic gear, weighing at least several hundred pounds.

Ability of the avionics designer to endow his systems with multi-function capabilities, or to micro-miniaturize construction so that the different systems required can compete more favorably with the pilot's weight will largely determine how fast the burden of aerial warfare shifts from piloted to pilotless aircraft.

Digital Computer

An excellent example of efforts to integrate functions with reductions in overall equipment size, weight and cost, is the central station digital computer.

In the past, a bomber carried a number of analog computers, each of which performed a specialized function and normally for only a portion of the total mission. There might be one computer for bombing, another for navigation, a third for bomber tail defense, a fourth to compute altitude-airspeed-temperature data, others for use in the integrated flight instruments, navigation aids and autopilot.

One airborne digital computer can perform all of these functions, and more. Using transistors and techniques developed in recent years, major reduction in overall size and weight is possible. One unit now under Navy test weighs only one-third as much as the individual analog computers it replaces and occupies only one-fifth as much space.

This means that an airplane or missile could be equipped with dual digital computers, one for standby to provide increased reliability, and still achieve significant savings in size and weight. (A proposal to use a central airborne digital computer in airliners for similar reasons was proposed during the recent meeting of the Institute of the Aeronautical Sciences [AW Feb. 11, p. 97]).

The progress which the avionics industry makes in improving the reliability of its products, despite increasing complexity, will also determine the pace of the trend to missiles. In a piloted aircraft, there are many failures which, thanks to the versatile human pilot aboard, will not wash out the weapon or the mission. This is seldom the case with a missile.

Reliable Reliability

Reliability of avionic equipment intended for missiles must be many orders of magnitude better than that required for piloted aircraft. And this must be achieved despite a more rugged operating environment and more cramped construction.

Reliability of avionic equipment does not need to decrease with increasing complexity, providing that suitable efforts are applied to root out basic controllable causes of unreliability. Two examples, recently cited by James M. Bridges, director of electronics in the Office of the Assistant Secretary of Defense for Engineering, are:

- **Fire control system** with 43,000 parts operates for three times as long between failures as an earlier fire control system with only half as many parts.
- **Airborne digital** bombing-navigation computer with 10,000 parts (including 300 tubes and 96 transistors) has operated for 450 hr., 135 of them in the air in tactical exercises, with only four failures. Only one of these affected the computer's flight availability.

Initially the fire control system cited above had a mean time between failures of only three hours, in contrast to its present value of 18 hr. The improved reliability resulted from a comprehensive program at Hughes Aircraft which included the prompt analysis of every failure during production test with speedy feedback of such information to the engineering department for immediate corrective action.

Similarly, the remarkable reliability of the airborne digital computer did not just happen. An extensive reliability program at Librascope determined the natural failure modes of the available components and led to design of circuits which avoided these natural failure tendencies.

One serious roadblock to improving avionic equipment reliability has been components. The equipment manufacturer criticizes the component manufacturer for failure to provide reliable components. To this the component maker replies that the equipment de-

Kennard and V. C. McIntosh of WRIGHT AIR DEVELOPMENT CENTER, Install Magnetic Tape Recorder in F-101 Aircraft.

Dynamics Section, Engineering Support Branch at Wright Air Development Center's Equipment Laboratory is primarily responsible for evaluating aircraft equipment under conditions of actual use . . . particularly vibration, shock, and acceleration. Under Section Chief D. C. Kennard, it records these phenomena as they actually exist in aircraft and missiles under all conceivable service conditions.

Prior to 1952, 12-channel recording oscillographs were used. But weight and size limited their use, as did the need for an operator to set attenuators for optimum sensitivity on each channel. Furthermore, the Dynamics Section is particularly interested in the frequency content of vibration, and the relative amplitude of each component frequency. But getting this information from oscillograph traces proved something of a problem. Visual examination was neither accurate nor complete. The Section resigned itself to using the 24-point method of Fourier Analysis in conjunction with punched card equipment, but was far from satisfied.

Searching for an entirely new approach, the Dynamics Section settled on magnetic tape recording, despite the fact that no suitable equipment was in existence. On November 2, 1949, in Exhibit MCREXE84-2, The Air Force called for the development of airborne magnetic tape data recording, reproduction and analysis equipment.

Among the responses to the exhibit was a proposal from the Davies Laboratories, Inc. Though the company had no previous experience with tape or recording, the ideas which Gomer L. Davies set forth in that proposal were interesting enough to gain his company the contract. Let on April 7, 1950, it called for three 14-channel airborne recorders, a 14-channel ground playback unit, and a dual channel automatic wave analyzer.

The combined efforts of Davies and his staff, and the Dynamics Section overcame obstacles that for years had chained magnetic tape to the broadcasting studio. The first system delivered to the Dynamics Section included such refinements as servo speed control for correcting low-frequency tape speed variations and a unique, completely elec-

(Advertisement)

MAGNETIC TAPE data recording Born: April 7, 1950

Today, magnetic tape is an accepted tool for data acquisition, processing, and storage. It has proved its worth in laboratories, industrial plants, even missile test centers. But a decade ago magnetic tape data recording did not exist. And without the inspired cooperation of a government agency and a private enterprise, it might not exist yet.

tronic compensation system for eliminating the effects of wow and flutter.

By 1952 magnetic tape data recording was a reality, with the delivery and acceptance of the first complete system for airborne use in November.

Substantially all the requirements set forth in the 1949 exhibit had been met. And several had been exceeded. The completely self-contained recorders were even smaller than specified. The three recorders so speeded up data acquisition that The Air Force immediately placed an order with Davies for four additional channels of analysis equipment.

With the introduction of magnetic tape data recording in November, 1952 as a full grown art, the technique was quickly adopted in laboratories, manufacturing plants, and government installations across the country . . . an amazing growth. But the record set by Davies equipment at Wright Air Development Center is impressive enough in itself. Davies recorders have been used there in testing every conceivable kind of aircraft, including:

F-86A F-86D B-36 B-45 B-47 B-50 B-52 B-57 B-66 C-47 C-54 C-123 C-124 C-130 H-19 KC-97 Q-2A RB-50

They have been used for ground testing at least ten different power plants. They have been taken to other military installations so that data recorded there could be analyzed on Davies equipment at the Dynamics Section. Most important, data made available by Davies equipment assisted in causing revisions in basic Air Force Specifications. It has been possible to prove, for example, the importance of high frequency vibration as a vital design consideration, and thereby eliminate an arbitrary upper limit of 55 cps on vibration testing.

Surely, magnetic tape data recording has been proved a development of vital importance. But it has even greater significance as an outstanding example of the benefits of a country in which government and industry can work hand-in-hand . . . cooperating on every level for the eventual betterment of all mankind.

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signer has misapplied the devices, subjecting them to operating conditions and environments for which they were not designed or intended. The equipment designer often retorts that it is the military who set the requirements and that he has to try to meet them with the best that is available.

If the component manufacturer's products are not of the required quality, one good reason is that all too frequently he fails to learn of component deficiencies in time to correct them. Equipment manufacturers find it difficult to get speedy reports on failures and their basic cause. Component vendors, once removed, get fewer reports.

Operational environment in a new missile or airplane usually exceeds the MIL specifications to which the components are beng manufactured. This means that the equipment manufacturer must run extensive qualification tests on hundreds of different components under the more severe environmental conditions. Such testing is expensive and time consuming and may therefore be limited or bypassed to meet delivery schedules.

Consumers Union

Collectively the hundreds of avionic equipment manufacturers spend millions of manhours and dollars annually on component qualification testing, yet few are able to keep abreast of needs. In dozens of companies across the nation identical, or nearly identical, qualification tests are being run.

No mechanism or organization existed by which manufacturers could exchange qualification test data with others in the industry in order to avoid duplicating efforts. (Some companies believe that such data is proprietary since they have run the tests, despite the fact that most such work is carried on under Government contracts.)

The Radio-Electronics-Television Manufacturers Association, following a recent survey that showed its members generally were eager to exchange qualification test data, considered establishment of a laboratory to handle such an exchange. Because RETMA is a trade association, restraint-of-trade considerations would prevent it from circulating reports on components which failed qualification tests.

Inland Testing Laboratories, a division of Cook Electric Co., recently proposed a plan to set up a sort of "consumers union" in the avionics industry. Under the plan, Inland would expand its present qualification test facilities and personnel and conduct wide scale component evaluations, then report findings to companies subscribing to its service. (AW Jan. 28, p. 100).

Representatives of major avionics companies, sounded out by Inland during the reliability symposium in Washington, were unanimously enthusiastic over the plan. In addition to providing avionic equipment makers with more component reliability data faster, the Inland service could also provide valuable data to component manufacturers, enabling them to correct product deficiencies.

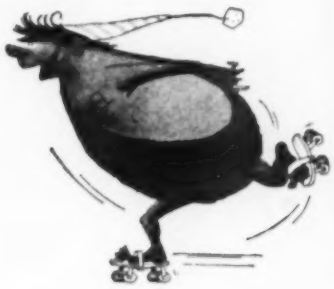
Unlike a piloted aircraft, which can be test flown to check out avionic equipment before a mission, the state of readiness of a missile must be fully determined on the ground.

This explains the growing trend toward complex fully automatic field checkout equipment for missiles and also for newer piloted weapon systems.

Automatic checkout equipment will be installed in a jeep or van, rolled to an airplane or missile and plugged in. The tester will then proceed to check out the performance of all of the avionic systems aboard, perhaps the hydraulic, pneumatic systems as well. When it finds a fault, the machine will automatically shift to another test routine to track down the fault to a specific black box which can be replaced on the flight line.

In one version, proposed by Sperry, the tester would even dispense a card not only identifying the faulty element, but also telling where to find a replacement, what tools and skills are needed for the repair, how long it should take, and detailed instructions for making the repair.

WHEELS IN MOTION...



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Controlling the tornado of intake air consumed by supersonic jets is the latest assignment of Giannini's High Resolution Pressure Transducer. This versatile instrument plays a key role in maintaining optimum efficiency of today's newest and most advanced high performance turbojet engines.

Two of these transducers form the heart of the Giannini designed and produced Variable Inlet Control System which limits diffuser air to a steady subsonic flow at all speeds and altitudes. Static and total air pressures in the diffuser throat are sensed by absolute and differential versions of the transducer, and this data is transmitted to a computing element. The ratio of pressures is compared to a stable reference, and error signals are fed back to position a variable obstruction, or ramp, in the inlet duct.

By using these unique pressure instruments as sensing elements in the Giannini system, several distinct advantages result: the transducers can be located near the pressure probes, minimizing pneumatic tubing length; no stable amplifier is required since the high level output of the transducer potentiometer pickoffs can be used directly; no repeater servo is required; the system is flexible, control pressure ratio being altered merely by adjusting the reference; the computer can be located remote from the transducers.

The Giannini Variable Inlet Control System is typical of applications to which this instrument can be put. **Capabilities** of 350 volt output, 2000 wire resolution, 0.8% linearity, repeatability to 1% of *reading*, and its rugged insensibility to vibration and shock make it ideal for use in the most critical airborne controls and systems... In case you're not interested in taming a tornado – perhaps it's only a mild breeze – Giannini High Resolution Pressure Transducers are admirably suited for telemetering and control applications requiring the ultimate in accuracy and sensitivity.

Giannini Variable Inlet Control System

Write for Bulletin 451212.

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Control Improvements Due in 1958

This year equipment is being designed and built, installations planned and sites surveyed, which will partially reshape and improve Common System navigation and control. But the impact of these improvements will not be felt by the men in the cockpits and control centers until 1958 or 1959.

Included in the catalog of improvements are:

• **Long range en route radar,** enough to practically blanket the high density airways in the east and to increase the radar traffic control radius around major airports from the present 30 mi. out to 200 or more. First set, in production at Raytheon, is for delivery late this year. All 23 civil en route radars, plus five air defense sets, should be in operation by late 1958 (AW Nov. 26, 1956, p. 39.).

• **Peripheral VHF-UHF** communication stations, some 250, which will make possible direct pilot-to-controller communications anywhere in the country for aircraft above 15,000 ft, and over much of the nation at lower altitudes. The Civil Aeronautics Administration hopes to get its new peripheral communications network into operation by early 1958.

• **Air traffic control beacon,** generally conceded to be as important to improved traffic control as en route radar and peripheral communications, will begin CAA evaluation tests this summer at New York, Chicago, Boston, Washington and Norfolk. Major airlines operating into these areas have begun to install service test transponders.

Weak Links

The strengthening of these key links in the traffic control chain will point up the weakness of other links—areas in which there has been slow progress or none at all.

These include:

• **Traffic situation display.** CAA's Technical Development Center has not yet found a good technique for displaying radar data in rooms with relatively high ambient light levels. Nor are good techniques in hand for coordinating such radar data with that appearing on long-used flight progress strips.

• **Point-to-point communications.** Traffic controllers spend much time accepting flight plan data by interphone or radio, calculating estimated times over fixes, then preparing flight progress strips. TDC has several programs under way aimed at developing techniques for automatic transfer of data by teletype and automatic preparation of flight progress strips or their equivalent. However, operational use of such systems is at least three to four years away, probably longer, unless an all-out effort is launched.

• **Air-ground data link,** or air traffic control signaling system (ATCSS). Despite a universally recognized need for a system which permits speedy transmission of routine traffic control messages between controller and pilot using visual display techniques to relieve congested voice communication channels, nothing is being done about it.

Support for ATCSS

The Air Coordinating Committee's as yet unreleased report prepared by its Special Working Group 13 has this to say about the need for ATCSS: "In areas where a high volume of aircraft operations must be accommodated, the use of voice only for air-ground communication will eventually be the limiting factor in the use of the airspace and a serious problem for the pilot and controller."

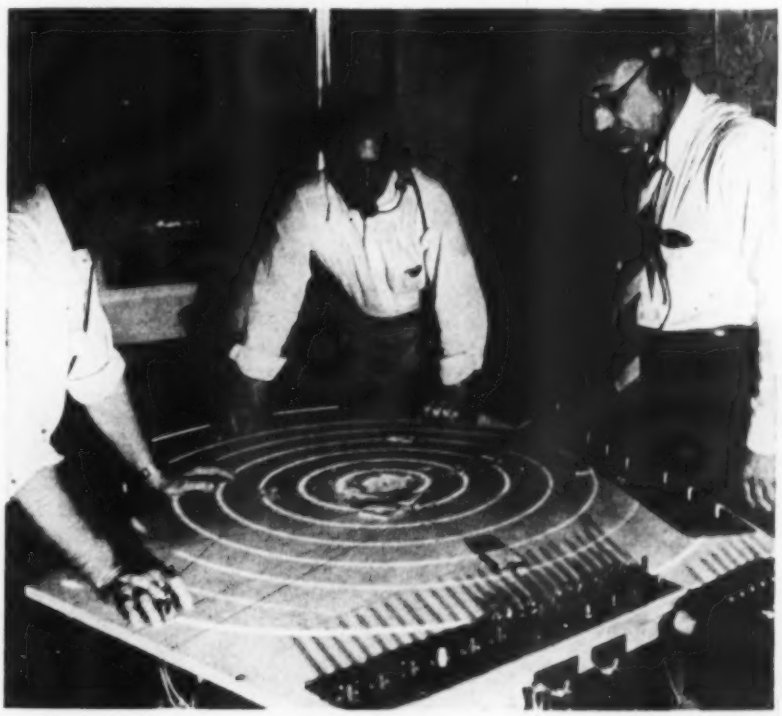
The President's special assistant for aviation facilities planning, Edward P. Curtis, recently expressed similar views: "We must, at least, augment our present over-burdened voice communications with some form of rapid simplified data link to pass essential information back and forth between controller and pilot, and between controllers themselves."

As far back as 1948 ATCSS was recognized as a future Common System need in the Radio Technical Commission for Aeronautics SC-31 report. A modest program launched by the Air Navigation Development Board was halted in 1953 because operational requirements were not sufficiently well defined and because it was felt that a number of classified military data link programs might provide useful techniques for Common System application.

Several military data link systems have been developed, including one by General Electric now going into Air Force use and another by Bell Telephone Laboratories for the Navy. Recently the Defense Department launched a program at Radio Corp. of America to develop a new data link system which will be standard for both Air Force and Navy.

Control vs. Display

These military programs have produced know-how which can be applied to a civil ATCSS system, although it is doubtful whether the military would declassify its equipment for use in civil aircraft. However, this possibility should not be ruled out for existing data link systems when they are eventually



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- **VIBRATION:** Withstands 15G to 2000 cps.
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In the Convair F-102A Rate Gyro System, Honeywell JR Rate Gyros instantaneously detect aircraft turning rates. Resulting output signals stabilize the aircraft throughout its entire range of speed and altitude. Teamed with other equipment, this Rate Gyro System makes possible uniform pilot control response for all flight conditions. Model JR Rate Gyros are also designed into a number of production and development missile programs. Honeywell products and engineering experience are available to assist in the solution of your Gyro system problems. *Write for Bulletin JR* . . . Minneapolis-Honeywell, Boston Division, Dept. 11, 1400 Soldiers Field Road, Boston 35, Mass.

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replaced by the new RCA system.

One important difference between the military and civil data transmission needs explains why the military system is usually called "data link" and the civil system is called ATCSS. Military systems provide both automatic control of the airplane from the ground and data display. Civil users are interested only in data display.

Some observers believe the civil system can be considerably less complex and costly than present military data links because of this difference in operational use. One interesting possibility is a TV-type ATCSS developed by Melpar, although it appears better suited to ground-to-air use than for air-to-ground.

The Melpar development might be called a "very-slow-scan TV" which can transmit any stationary picture (letters, numbers, maps). This picture is displayed in the cockpit on a cathode ray tube, which conceivably could be the same unit used for airborne radar. The system has the advantage of being relatively simple and can be operated from most of the new VHF communications receivers using a suitable adaptor-converter.

Action Needed

Before any progress can be made in ATCSS, it will be necessary to get all Common System airspace users to agree on operational requirements—what capability is needed, required capacity, and the type of display. This will broadly define the technical parameters of the required system. Only then can specific hardware development begin.

While everyone talks hopefully about the potentialities of ATCSS in relieving present voice communication congestion and traffic controller load, basic problems confront any group attempting to formulate Common System standards and needs.

Unless the vast majority of airspace users, including private aircraft, are ATCSS equipped, the traffic controller will have to alternate between voice and ATCSS which may actually result in less, not more, communication efficiency. Thus the ATCSS system selected must permit the use of minimum equipment, providing at least minimum service, to airspace users who can afford nothing better.

Furthermore, from the traffic controller's standpoint, the air-ground ATCSS should operate compatibly with a controller-to-controller ATCSS for maximum efficiency.

VHF communications equipment that CAA has ordered for its new peripheral communications network will be its first with 50 kc. channel spacing, compared to existing 100-200 kc. spacing. When airspace users install equivalent 50 kc. channel equipment, it should roughly double available

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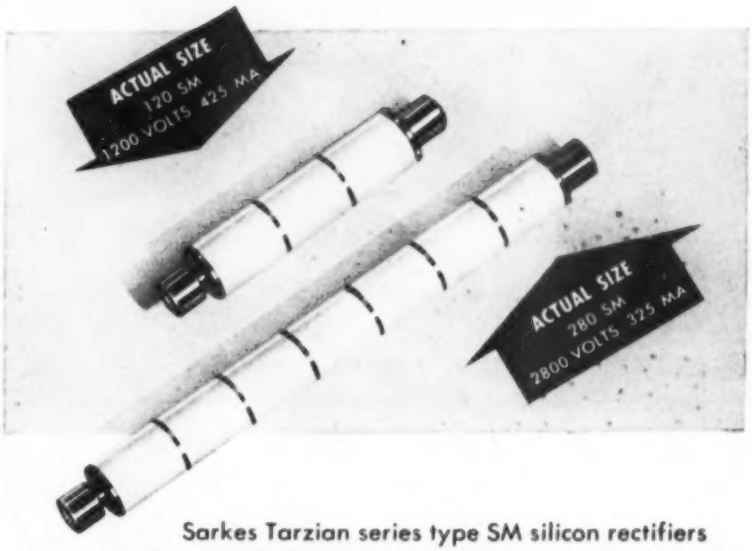

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80SM	800	560	450	225	1 12	560	4 5	2 25	27 0	13 5	1N1108
120SM	1200	840	425	212	1 06	530	4 25	2 12	25 5	12 7	1N1109
160SM	1600	1120	40	200	1 00	500	4 00	2 00	24 0	12 0	1N1110
200SM	2000	1400	375	187	940	470	3 75	1 87	22 5	11 2	1N1111
240SM	2400	1680	35	175	875	437	3 50	1 75	21 0	10 5	1N1112
280SM	2800	1960	325	162	812	405	3 25	1 62	19 5	9 7	1N1113

DIMENSIONS

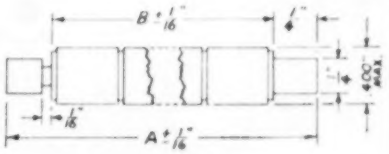

Figure 1

Figure 1 A	Figure 1 B	JETEC NO
1-15/32"	31/32"	1N1108
1-15/16"	1-7/16"	1N1109
2-13/32"	1-29/32"	1N1110
2-7/8"	2-3/8"	1N1111
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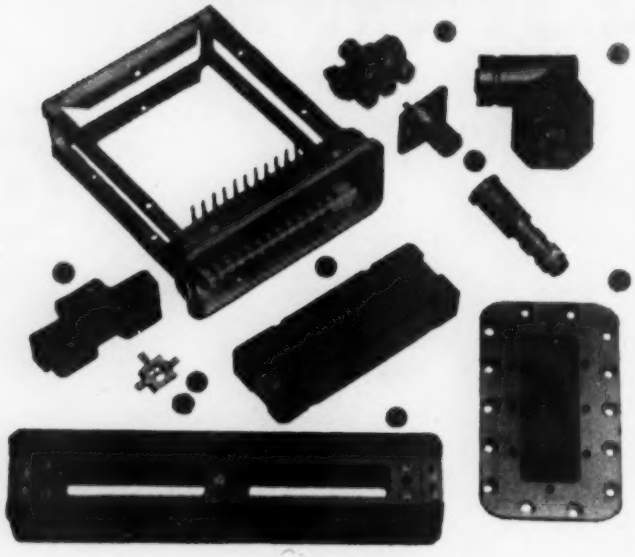

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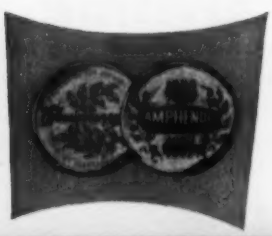

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channels, greatly easing present congestion. However, it probably will be 1959 before the majority of airlines are so equipped.

Increased use of direct pilot-controller communications will largely eliminate working through individual airline radio operators who in turn relay the message. But this raises problems for the airlines who then find it more difficult to contact their aircraft.

One possible solution, being tried in the New York Air Route Traffic Control Center, is to allow the airlines to tap into the controller's receiver to monitor conversations with their own aircraft. However, each airline must listen in on a variety of conversations with other airline aircraft. A more economical solution may be for airlines to pool their efforts and set up a central monitor.

Another solution is the wider use of selective calling (Selcal) equipment. This enables an airline radio operator to flash a light in the cockpit of an individual aircraft alerting the crew to call the airline station.

Teletype Capacity

ACC's report by SWG-13 points out that teletype networks used to collect and disseminate weather data are badly overloaded. Despite greatly increased weather data now available and greater airline need there has been no basic increase in teletype capacity in the past 10 years, except for a 20% increase in teletype operating speed.

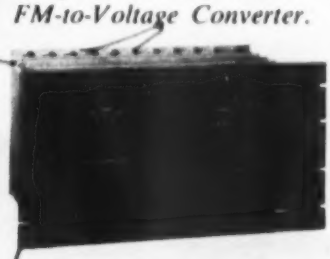
"As a result we are trying to disseminate a volume of data far in excess of circuit capacity," SWG-13 says, "which often results in serious delays in receipt of vital weather data. Frequently much data cannot be sent at all, or is withheld at relay points. Thus pilots and controllers don't know whether the weather has changed sufficiently to affect adversely aircraft operations and air traffic control service."

ANDB is investigating an extremely high-speed teletype system which may eliminate this present bottleneck. It hopes that a single such high-speed system can replace the three different meteorological services now in use, yet provide all information of interest every hour. The system would permit each station to pre-select the specific weather data of interest to it.

Because radar is more glamorous and more recent, the basic fact is often overlooked that the heart of any traffic control system is communications—between pilot and controller and between controllers. The CAA's multi-million dollar program, which will double the number of traffic control radio receivers and transmitters within two years, is heartening evidence that at least one phase of the communications problem is headed for solution.

NEW! ultra-stable FM Telemetering Discriminator*

**Epsco Model FM-108 FM-to-Voltage Converter.*



EPSCO'S MODEL FM-108 crystal-controlled ultra-stable, all-channel discriminator presents a new *standard of accuracy* . . . better than an order of magnitude more accurate and stable than any other commercially available equipment . . . and with absolutely *no* adjustments! This new standard of FM data processing features:

- **HIGH DYNAMIC ACCURACY:** Absolute accuracy is better than 0.05%, and the dynamic accuracy of the equipment from input to associated band-pass filter through the low-pass output filter is better than 0.2%.
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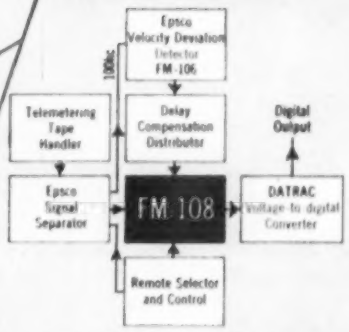
- **AUTOMATIC WOW and FLUTTER COMPENSATION:** With Epsco FM-106 Velocity Deviation Detector and Epsco CD-601 Velocity Deviation Compensation Distributor, errors from tape speed variations are reduced by a minimum of 35 db.
- **ZERO and 100% DATA CORRECTION:** Produces automatic compensation for variation of transmitting sub-carrier oscillator frequency and gain by a transistorized electro-mechanical servo feature.
- **DYNAMICALLY ACCURATE SELECTABLE LOW-PASS FILTERS:** 6 5-pole filter utilizing precision wire-wound resistors and ultra-stable polystyrene capacitors in combination with chopper-stabilized d-c amplifiers provides:
  - Phase linearity deviation not exceeding 0.25 degrees over 90% of bandwidth.
  - Pass band flat within ±0.1% (0.01db) to F_c.
  - Minimum attenuation of 54 db of nearest beat frequency between sub-carrier channels.
  - A total of 62 different low-pass filter bandwidths selectable from 11 cps to 3490 cps.
- **PHYSICAL CHARACTERISTICS**

  SIZE: 10½" of space of standard 19" cabinet.
  WEIGHT: 29½ pounds.
  CONSTRUCTION: Constructed of 8 separate plug-in chassis assemblies containing electronic and magnetic components. All components are accessible on the standard layout forms.

Engineering data sheet available on request.



Epsco Model BF-601 Signal Separator units, each of which contains 23 band-pass filters, are available for separating the composite sub-carrier signal prior to input to FM Converter.

Complete FM telemetering receiving stations are available with or without wow and flutter compensation and zero and 100 percent correction features. Also available is the Epsco Model VCO-718 All-Channel Voltage-Controlled Oscillator for FM Discriminator calibration . . . which occupies only 3½ inches of panel space including power supply.

In the West, contact:
Epsco Service Corporation of California
1722 Westwood Boulevard
Los Angeles 24, California

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588 COMMONWEALTH AVE., BOSTON 15, MASSACHUSETTS

Completely TRANSISTORIZED AMPLIFIER & SERVO MOTOR

Heat rapidly dissipated by unique heat-sink design.
No output transformer needed—amplifier works directly into Oster-designed size 10 servo motor with center tapped control winding.

AMPLIFIER DATA

- Input Impedance: 2500 ohms.
- Load Impedance: 250 + JO ohms. This is the 400 cycle stall impedance of an Oster Type 10-5054-03 servo motor control phase when resonated with 2.0 microfarad capacitor.
- Power Gain (open loop conditions—no negative feedback): 50 D. B. minimum.
- Power Output: 0.5 watt minimum.
- Power Requirements:
  + 19.5 Vdc—250 ma.
  + 4.5 Vdc— 20 ma.
  + 8.5 Vdc— 6 ma. (regulated ± 5%)
- Amplifier Rating: 0.5 watt min. at 25°C.
- Environment proof operation assured by encapsulation of amplifier assembly.

SERVO MOTOR DATA

- With .015V at 400 cycles applied to amplifier input, motor pinion rotates 5000 RPM minimum under no load conditions.
- With .075V at 400 cycles applied, motor develops .15oz.-in. minimum stall torque. Minimum speed 6200 RPM under no load conditions.
- Up to 0.2 oz.-in. torque can be obtained by energizing the reference phase with 31.0V if motor has an adequate heat sink. This results in a reference phase current of approx. .210 amperes.

Engineers for Advanced Projects:
Interesting, varied work on designing transistor circuits and servo mechanisms. Contact Mr. Zelazo, Director of Research, in confidence.

Input impedance variations to meet your specific requirements can be made. Write for additional information today.

Other products include actuators, servos, synchros, AC drive motors, servo mechanism assemblies, DC motors, motor-gear-trains, fast response resolvers, servo torque units, reference and tachometer generators, synchro indicators and motor driven blower and fan assemblies.

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HELICOPTERS

Volume of Complaints Measures Need for

New York—Continued criticism of the helicopter industry from military and civilian users is as much a recognition of its vast potential as it is of frustration of the customers who feel manufacturers are dragging feet in serving their needs.

Basic problems remain: lack of large transport-type vehicles, complexity and attendant high initial and operating costs of the aircraft now available, lack of all-weather capability.

Rotary-wing manufacturers' design staffs are spread thin trying to cope with solutions, so what progress is being made is too slow to dim the ire of the user.

It is evident that helicopter builders are losing important sales volume. Army's aviation director, Maj. Gen. Hamilton H. Howze, told American Helicopter Society:

"I hope you understand that a low availability rate for helicopters does not by any means increase the requirement for them. Its effect is quite the opposite: low availability and high initial and continuing expense make the article too rich in terms of cost per ton-mile for the military to stand, and decrease the quantities of our purchase."

Worse still are signs that the Army—the industry's biggest customer—is leaning toward new developments in fixed wing aircraft to replace the helicopter in some tasks.

This factor was presented by Gen. Howze before the House Subcommittee on Appropriations early last year when he stated:

"We think that there is considerable possibility in the development of fixed-wing transport aircraft with vastly improved short field capability, not to replace the helicopter, but to substitute for it on certain of the missions for which we now have no choice but to depend on the helicopter."

In addition to feeling that the fixed-wing type would be more efficient aerodynamically, Gen. Howze also mentioned that Army feels that it would be cheaper and easier to maintain in the field.

Army faces a weight barrier on this proposition, since it has to contend with the Joint Chiefs' 1952 Memorandum which limited its fixed-wing aircraft inventory to 5,000-lb. empty weight types.

The new STOL development mentioned by Gen. Howze before the House Subcommittee would have a three-to-five-ton payload. But this thinking does reveal some Army feelings about helicopter shortcomings.

A slow-down on Army interest in large personnel helicopters could have a serious effect on civil transport types, since the industry has felt a dependence on military funds to write-off their development.

All airline helicopters now flying or projected for the near future have had a military forbear.

Flying Crane

In place of the big personnel helicopter, the Army is studying "flying crane" development, rotary wing aircraft stripped to essentials minus the weight structure of conventional cabins. Five study contracts, totaling $264,900, have been awarded five manufacturers, while other firms are independently working on similar projects. Range would be 10-100 mi., cargo capacity would be to 16 tons.

Indications are that a major part of the industry's problems in meeting strident demands for more efficient, more economical machines, may be traced to the multiplicity of projects and development loads it has accumulated. These are due partly to overzealous selling and partly to good-intentioned but over-enthusiastic supporters who imagined that the helicopter was the immediate answer to their dreams. Deprived of a normal adolescence, as the fixed-wing industry enjoyed, relatively small companies were called on to expand production at almost the same time they were asked to develop machines ranging in size from 1-man flying platforms to big transports. In addition to developing the basic airframe, they also had to design and prove out rotor systems, transmission; utilize modified

HILLER XROE-1 ROTORCYCLE

Helicopters

fixed-wing powerplants, unsuitable instrumentation.

There is little doubt that criticism might also be directed to equipment suppliers who have been slow to supply the helicopter manufacturers with specially designed products, lighter in weight, simpler in construction, and suited to the new environment.

Optimism Undimmed

The industry continues to roll with the punches and feel enthusiastic about its future. Harvey Gaylord, president of Bell Helicopter Corp., Ft. Worth, Tex., recently predicted that his company's commercial business will total $30 million by 1970. Last year Bell's civilian helicopter dollar volume was approximately $8.5 million.

At mid-1956, the U. S. helicopter industry had total sales approximating $141,703,000 with $119,732,000 of this going to the military. Backlog at that time amounted to $472,060,000, of which the military accounted for $422,294,000. Export sales, not including MDAP deliveries, for January through December, totaled 178 units valued at $28,700,485.

Apart from the dollar importance that the military plays in helicopter sales volume, the brightest spot commercially has been the boom sparked by industrial and executive users, particularly the former.

Industry search to uncover and develop natural resources throughout the world has carried the rotary wing aircraft with it. In offshore oil exploration in the Gulf of Mexico, helicopters worth an estimated $5 million-plus are carrying thousands of passengers and uncounted tons of cargo monthly (AW Dec. 31, 1956, p. 27).

Similar projects are underway around the world.

Industrial Impact

The impact of such industrial work and the use of helicopters for executive transportation is seen in these recent figures from Bell: heavy concentrations of rotary wing aircraft in the Western Hemisphere include 15 Bells along the Gulf of Mexico, 50 along the West Coast of the U. S. and Canada, 30 in South America along the Caribbean Coast, 40 more throughout the Eastern U. S. and Canada and 30 in the Midwest area of the U. S.

Including Bell 47s operated by foreign government non-military agencies, there are 550-600 various models of this type in commercial operation, of which 150-200 are domestically flown. On business operations alone, Bell estimates

COMMAND & RECONNAISSANCE

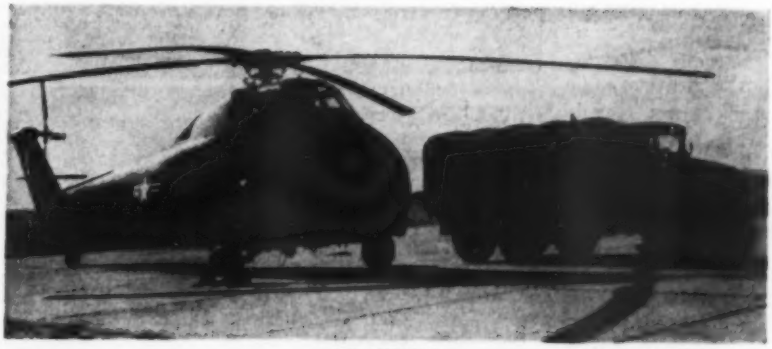
AIR VEHICLE
¼ ton
70-120 mph.

GROUND VEHICLE
¼ ton
15-25 mph.

UTILITY

AIR VEHICLE
¾ ton
70-120 mph.

GROUND VEHICLE
¾ ton
15-25 mph.



CARGO

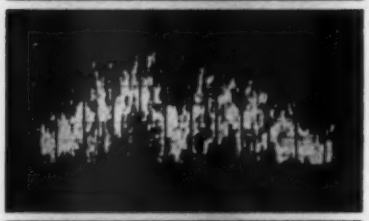
AIR VEHICLE
1½ ton
70-120 mph.

GROUND VEHICLE
2½ ton
15-25 mph.

How you can "squeeze" 64 simultaneous messages into a single frequency

Breaking communication bottlenecks is a specialty of the Hoffman CV-157 Dual Sideband Converter. In one quarter the space of previous sideband converters it achieves maximum use of today's limited frequency bands, relieves traffic overloads. The CV-157, designed and developed by Hoffman, receives independently modulated AM signals with a highly suppressed carrier and splits them into two sidebands. Result: up to 75% greater effective range without increasing transmitter power—2 to 32 times more traffic capacity without increasing frequency bandwidths. As many as 64 dualtone teletype channels, or various combinations of teletype, facsimile and AM voice can be handled by the CV-157. Write today for additional data on this and other advanced communications techniques now under evaluation at Hoffman.

Scope pattern taken from Hoffman CV-157 showing two dualtone teletype channels on upper sideband, carrier partially suppressed. Each sideband can carry 32 teletype channels at one time.



One AM voice channel (made by continuous vowel sound) on each sideband, carrier completely suppressed. CV-157 carries two 3KC voice channels on each sideband.

AM voice on lower sideband, dualtone teletype channel on upper. With suitable multiplexing equipment, the CV-157 handles 64 simultaneous dualtone teletype channels.

ALL PHOTOS UNRETOUCHED FROM PANALYZOR MODEL SB-8

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Significant developments at Hoffman in the fields of VLF, HF, VHF, UHF, forward scatter and tropospheric communications, single sideband and advanced ECM techniques have created important positions for engineers of high calibre. Please address inquiries to Vice-President of Engineering.

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that its 47s are accumulating more than 20,000 hr. annually.

Increased scope of industrial operations is creating a demand for the large S-58, costing well over $300,000, with some operators planning to jump directly from the little Bells to the big machines. "It's amazing," a Bell sales representative recently told AVIATION WEEK, "It seems like only a little while ago one of these operators was haggling with me over the price of a 47 tail rotor; now I hear he's planning to get an S-58."

Airline Progress

Scheduled helicopter passenger and cargo operations showed promising increases last year, although they still need Civil Aeronautics Board subsidy necessary because of heavy operating costs.

The three regular operators, New York Airways, Chicago Helicopter Airways, Inc., and Los Angeles Airways reported an increase of 150% in passenger miles in 1956 over the preceding year. Passenger revenues were up about 100%.

New York Airways reported an 80% jump in number of passengers carried in 1955 for a total of 43,000. Scheduled passenger miles were up 69% for a total of 802,079; express loads went up 58,328 lb. to aggregate 1,917,618 lb.; freight to 608,040 lb., an increase of 134,255. Mail was down 18% for a total of 1,156,172 lb.

Probably the most outspoken of the domestic helicopter airlines, NYA lets the industry know that it is constantly evaluating rotary wing aircraft, regardless of their nationality, in its effort to find equipment cheaper in price, larger in capacity, more economical to operate.

High Cost

It opened its campaign early this year. In January, Glen B. Eastburn, assistant to the president, acknowledging the carrier's gains in 1956, said that NYA could not be satisfied with completion of 85% of its schedules and that the subsidy of 75% of the cost of the operation is uneconomic and can be tolerated only temporarily. He pointed out that the S-55s operated by the carrier have a seat-mile cost of approximately 70 cents, or a ton-mile cost of about $75, considered 'fantastic unless engineering and economic factors point to a better day for the helicopter."

Other charges leveled by Eastburn:

• **"Depreciation,** maintenance and flight operation costs . . . in our experience . . . in about four hours a day operation . . . are roughly the same level . . . all too high.

• **"Many of the details** of cabin and operational accessories are unduly expensive because of special design and sometimes are too awkward to handle. Why should it require removal of the insulation of the ceiling and walls to change the light bulb in a late design cabin?"

• **"Why should** the rotor head have to be returned to the factory for corrosion treatment when civilian operations proved such was required on previous models?

• **"After four years** of operating one helicopter model (S-55), the parts catalog has finally become a useful and dependable handbook for maintenance."

Local governments also pose difficulties for the operator; NYA finally began operations into a downtown New York heliport Sept. 26 after a long-term squabble between city officials, New York Port Authority and CAA. As of May 1, NYA will begin round-the-clock passenger, mail, cargo and express flights from the waterfront heliport.

With introduction of its 12-passenger S-58s to this landing site and the day-night operation, it expects triple the number of people being served at the facility.

Reason Army is one of the stanchest critics of the industry is that it be-

HILLER YH-32

BELL 47J

OKINAWA RESCUE—The 28-man crew of an Army tug was rescued by a Sikorsky H-19 of the U. S. Air Force's Air Rescue Service after the tug was wrecked on a reef off Naha, Okinawa. The tug went aground aiding the Army coastal tanker in the background, also stranded on the reef.

AROUND THE WORLD WITH SIKORSKY HELICOPTERS

WORLD'S FASTEST—A Marine Corps Sikorsky HR2S-1 has set a world record of 162.7 mph. Flown by Major Roy L. Anderson, left, and Robert Decker, Sikorsky test pilot, the HR2S also set new records carrying 13,250 lbs. to 7,000 feet (surpassing a Russian record), and 11,050 lbs. to over 12,000 feet.

NEW RADAR HELICOPTER—Under development for the Navy by Sikorsky Aircraft is this HR2S-1W helicopter with radome accommodating search radar gear. It can extend radar coverage beyond the range of shipboard radar or land-based radar picket aircraft.

CHICAGO AREA passenger service has been inaugurated by Chicago Helicopter Airways, using Sikorsky S-55s of the type which pioneered in similar operations in New York and Los Angeles.

IN EUROPE, Sabena Belgian World Airlines has received the first two of a fleet of 12-passenger Sikorsky S-58s. Landing at Brussels, above, after a delivery flight from Paris, an S-58 averaged 146 mph for the 185-mile distance, setting a new city-center to city-center record. Sabena started commercial helicopter service in Europe with Sikorsky S-55s.

HELICOPTER HISTORY

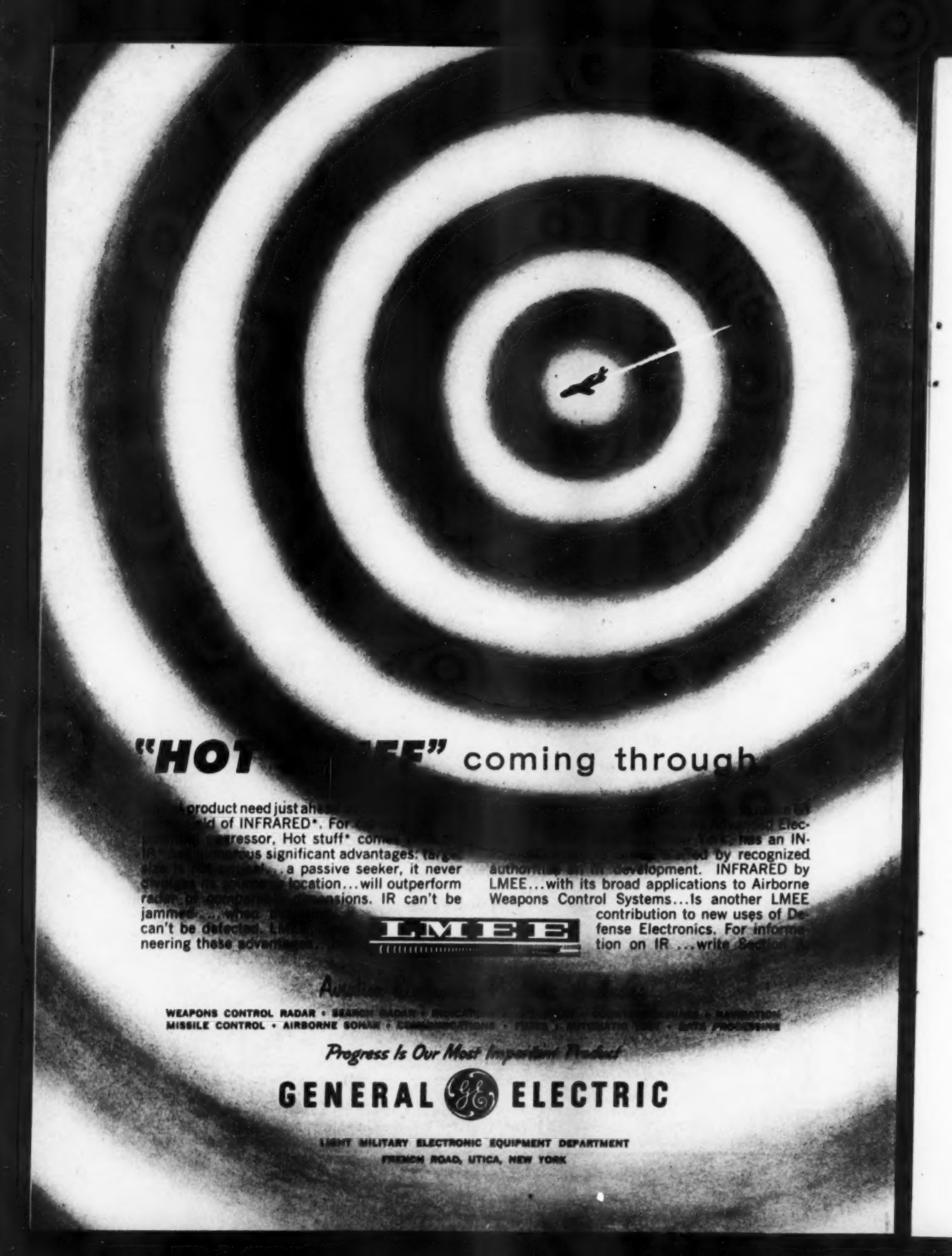
FIRST SIKORSKY SPEED RECORD

On June 3, 1946, at Dayton, Ohio, an Army Air Force's Sikorsky R-5A, above, flew 110.849 mph. This was a world record for maximum speed without payload over a 20-kilometer course.

SIKORSKY AIRCRAFT

BRIDGEPORT, CONNECTICUT

One of the Divisions of United Aircraft Corporation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FRENCH ROAD, UTICA, NEW YORK

lieves so much of its future depends on suitable helicopters if it is to survive as a military service.

It feels that in the vital ingredients of military tactics—firepower and mobility—the former, incorporating nuclear weapons and missiles, has greatly outstripped the latter. The helicopter, Army feels, will play an essential role in permitting the dispersion and mobility it vitally needs. Outnumbered on the ground by its potential enemy's huge armies, the ability to move reserves to stave off an attack or mount an offensive with minimum delay can mean the difference between victory and defeat.

All-Weather Lack

One of the most critical factors it currently faces is lack of all-weather helicopter capability, which severely limits ground force tactical possibilities.

The Marines, aware of the effect of nuclear weapons upon a tightly grouped invasion force, are developing new helicopter assault tactics around special carriers. First of these, the Thetis Bay, was launched last year after an $8 million reconversion. Capable of carrying 20 Sikorsky HRS helicopters and 1,000 Marines, Thetis Bay will be used to develop new amphibious doctrine and serve as the prototype of later helicopter carriers built from the keel up.

The Navy, a firm proponent of the helicopter, particularly for use against the potent threat of submarines, can be expected to expand its carrier-borne rotary wing ASW force, relieving the fixed wing S2F type of much of its operation.

Navy is also expending considerable effort on human engineering to make the helicopter easier to fly and to provide it with specialized instrumentation for all-weather operation.

New Equipment

Helicopter design and development continues unabated. A significant highlight last year was the first flight of the Army's new H-40, six-seater powered by a Lycoming T53 gas turbine and featuring design for simplified maintenance. Bell expects military orders for the H-40 to figure importantly in its future contract volume, also contemplates a seven-passenger commercial model. The craft is built to pass CAA requirements.

Bell also previewed its new four-place 47J Ranger executive/utility light helicopter in the lucrative South American market with a 17,000-mi. flight that by early this year had resulted in 15 orders, including foreign military sales. It is also producing the 47J for the Navy in utility and trainer versions.

Rollout of the first production Cessna YH-41 light helicopter is ex-

(Advertisement)

Valve Talk

FOR WM. R. WHITTAKER CO., LTD.

BY MARVIN MILES

"Pilots, man your planes!"

The Shangri-La's bull horn reached across the big carrier's wind-swept deck as she pounded through the long Pacific swells.

My pilot swung easily up the shiny flank of the big twin-jet Douglas Skyknight and I followed, ready-rigged in flight suit, life jacket, crash helmet and oxygen mask.

I was still latching up buckles and plugging in lines as deck crews jockeyed the jet job on to the aft end of the catapult amidst eerie swirls of steam from the last launch.

I had gone aboard the 889-foot flattop to see the three British innovations that have revolutionized carrier operations — the angle deck, the mirror landing system and the steam catapult. A cat launch was to be the climax of my study.

The steam catapult has a longer, smoother, more powerful stroke than the old 120-foot hydraulic types and can launch much heavier planes, flinging them to jet flying speeds with little or no wind over the deck. With the old catapults the limiting factor was the cat itself. Today, with steam, the limiting factor is the plane.

The 208 feet of track up ahead was foreshortened in appearance to 50 feet, ending abruptly at the bow line. In this distance our 23,000-pound Skyknight would be hurled to a flying speed of 161 m.p.h.

Overhead, the canopy was locked partway open for easier escape if we should splash. A pacing destroyer and a hovering helicopter were comforting sights to port and starboard.

My pilot gave a quick signal salute to the launch crew and we both braced our heads hard back against the seats. I saw he had braced the stick with his right elbow jammed into his body to prevent an inadvertent pull-back under acceleration. His throttle hand was similarly safetied by a straight-stiffened left arm.

Held by the bridle hooked to her belly, the Skyknight shuddered heavily under the full blast of her two jets. Then the launchman pushed the button.

Instantly the three-fold weight of gravity slammed into us with the shock of a pro-halfback at full run. The Skyknight leaped toward the bow and the acceleration Gs jumped my weight from 160 pounds to an immobilized 480 pounds.

The run, actually less than two seconds, seemed interminable and I found myself grimacing behind my oxygen mask as the clutch of gravity squeezed me helpless against the seat.

Then the deck blurred from under the jet, leaving only the restless gray sea beneath. There was no dip, no falter. The G-pressure vanished, releasing us from bondage. The Skyknight nosed up, docile now after the fury of her launching by the world's most powerful sling shot . . .

The Shang was the first American carrier modified with the angle deck and seeing it in operation, so simple in theory, it seemed incredible it wasn't thought of long ago.

The landing strip, angled slightly off the fore-and-aft line of the ship, eliminates committing a plane to the barriers if it doesn't catch a wire. The pilot simply guns his engine and goes around again without barriers or parked planes to worry about. And up on the foredeck, launching crews are no longer concerned about a landing plane bounding over the barriers to spread death and destruction aboard.

Angled separation of landing and launching areas gave carrier operations vastly increased safety and faster, smoother operations at a time when the advent of heavier, high speed jets posed a rough problem for straight-deck flattops.

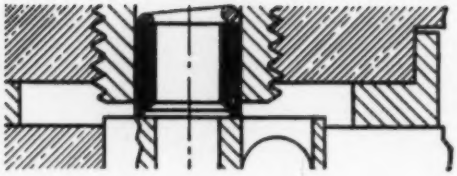
The third innovation aboard the Shang is her new mirror landing system that has banished the familiar paddles from the landing signal officer's hands and may well banish the colorful LSO altogether.

A concave mirror some four feet square, mounted on the seaside edge of the landing deck, reflects a spot of light from a series of yellow-amber lights focused on it from the deck some distance aft.

If a landing pilot holds the light centered in the mirror—judged by a row of green datum lights extended outward on both sides at center level—his touchdown will be perfect and his tail hook will invariably catch No. 3 wire.

If he's too high, his line of sight will show the guide light above the datum line. If he's too low the light will appear below the line. To stay in the proper landing groove he has only to correct to keep the light in the center of the mirror, for the spot is beamed upward on the sink rate (normal descent) of each individual type plane.

Angle deck — steam launch — mirror landing...atomic power next!



MECHANICAL ENGINEERS

Continually expanding programs at Northrop Aircraft are creating new opportunities for mechanical engineers in the following areas: launching and landing gear design, hydraulics and pneumatics, control systems, and equipment.

You'll enjoy the fine spirit of cooperation at Northrop. The new multi-million-dollar engineering and science center, now nearing completion, will be a great place to work in, both as to its modern architectural design and newest scientific installations. You'll be associated with a top engineering team on such notable projects as Northrop's new supersonic trainer airplane, Snark SM-62 intercontinental missile, and other advanced aircraft and missile programs.

You'll be given constantly fresh, challenging assignments. Remuneration will be substantial, with many benefits that are unexcelled in the entire industry—health and life insurance, college educational reimbursement plan, regular vacations plus extra year-end vacations with pay, and a generous retirement plan.

At Northrop, the progress of personnel is important. Initiative and ability are recognized and encouraged, and full opportunity is given to present and discuss ideas.

You will find the career opportunity you are seeking at Northrop, pioneer in the design and production of all weather and pilotless aircraft. If you qualify for one of these attractive positions, contact the Manager of Engineering Industrial Relations, Northrop Aircraft, Inc., ORegon 8-9111, Extension 1893, or write to: 1015 East Broadway, Department 4600-O, Hawthorne, California.

NORTHROP

NORTHROP AIRCRAFT, INC., HAWTHORNE, CALIFORNIA

Producers of Scorpion F-89 Interceptors and Snark SM-62 Intercontinental Missiles

pected this year. Delivery of commercial models is at least another year away due to prior military commitments, but even Bell sources admit that they expect the new Cessna to give them solid competition, particularly in view of its simplified rotor system. Bell has been busy redesigning the rotor system of its competitive 47 model to reduce substantially the initial and maintenance costs. Fact that Cessna has a large distributorship organization that could be trained to take on the CH-1 and provide convenient service locations is another factor that could help promotion.

Simplicity Quest

Omega Aircraft Co., New Bedford, Mass., flew its new SB-12 twin-engine single-rotor helicopter late last year. Although capable of carrying four passengers, the SB-12 embodies some features of "flying crane" configuration that make it particularly suitable for cargo carrying. Prime feature is simplification of components for easy maintenance. Of its 19 bearings, 17 are automotive parts (AW May 7, 1956, p. 50).

One-man flying platforms continued to make their appearance: Hiller has a new three-engine version of its previous model flying, DeLackner started deliveries to the Army for evaluation purposes late last year.

Hiller began deliveries of its YH-32 ramjet-powered two-place helicopter to the Army at Ft. Rucker, Ala. Single rotor YH-32 has a 40-lb.-thrust powerplant at each blade tip.

A tilting-wing turboprop aircraft for USAF and a ducted fan vehicle for the Army are the two main projects development at Hiller.

Hiller also introduced its Rotorcycle entry, the XROE-1.

Early Warning

Sikorsky flew the HR2S-1W, an early-warning version of the twin-engine, single main rotor S-56. The S-60, a Sikorsky flying crane project with turbine engines and a cargo pod space under a long, wide-spaced landing gear, was revealed.

Kaman flew its HOK-1 fitted with a Lycoming T53, first U.S. helicopter to fly with a gas turbine engine.

Goodyear developed a fabric rotor blade, using the principle of woven inflatable structures. It is testing the inflatable blade on its GA 400-R Gizmo one man helicopter.

Work continued on various configurations, attempts to conquer helicopter stability or complexity problems with unusual layouts. Gyrodyne Corp. disclosed one such system, blade tip brakes on a coaxial one-man helicopter, used to control the helicopter in autorotating descents.

Stepped Aluminum Extrusions

By C. J. Huffman, Technical Superintendent
Kaiser Aluminum Halethorpe (Md.) Extrusion Works

Figure 1

Many developments have been made throughout the years to modify the extrusion process and the basic equipment. New and more difficult tasks are being demanded daily of this highly flexible tool. Industry has played an important part in the advancement of extrusion technology through their demands for more complex sections, closer tolerances, and new materials. Typical of the extruded products resulting from aircraft industry demands is the stepped extrusion. Fig. 1.

Initially these efforts were spurred on to overcome the volume and weight limitations of existing equipment. Placing material where it is required along the extruded length makes it possible to design integral connecting lugs and obtain the longer lengths required. Aircraft designers quickly took advantage of the simplified design possibilities with stepped extrusions. Economic advantages became evident with reduced raw material costs and decreased machining requirements.

A variety of methods have been devised to produce extrusions with variable cross sections throughout the length. Early patent literature describes the use of tapered or stepped mandrels used to produce tapered hollow extrusions which were split longitudinally to produce relatively simple sections. Extrusion dies with externally operated movable segments have been described in great detail to produce tapered and stepped parts. These were the forerunners of the step extrusion processes which are in common usage today. Step extrusions are commonly produced at the present time utilizing two sets of extrusion dies. The small or minor section is extruded first to the desired length at which point the extrusion cycle is interrupted long enough to change dies to produce the major configuration. In most cases the dies are comprised of two segments to facilitate removal of the dies from the extruded part. Fig. 2 represents a schematic tooling arrangement and operational sequence for this method of producing stepped extrusions. A modification of this process is allowed through improved press designs utilizing a secondary locking arrangement to hold the minor section dies in position. If single piece dies are used the minor must be stripped off the end of the extruded section with the major die being threaded over the end of the minor part.

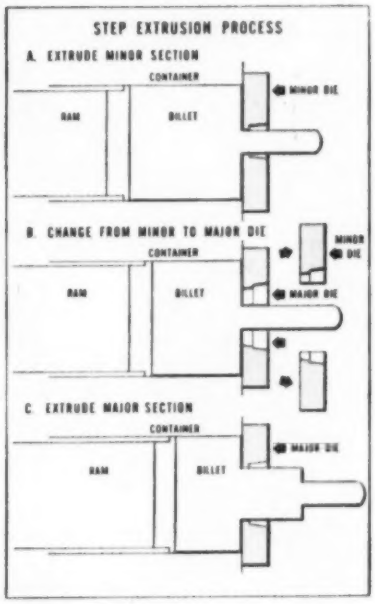


Figure 2

In working from the finish machined part to the stepped extrusion requirements, dimensional tolerances are of prime importance to insure ability to manufacture the desired part yet avoid an excess of stock. Stepped extrusion tolerances have not been standardized throughout the industry at present; however, the following are typical of those that can be obtained today. These differ primarily from normal extrusion tolerances in straightness and step area dimensions. The straightness of the overall part is measured by deviation from a reference line with the junction area (8" on either side of the step) being excluded. Fig. 3.

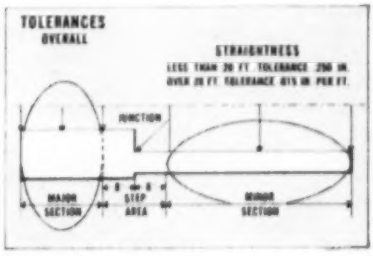


Figure 3

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Kaiser Aluminum

The straightness of minor and major positions of the extrusion is determined individually with the junction area being excluded. The minor and major positions are usually furnished to standard extrusion straightness tolerances.

Due to the change of flow conditions in extruding the major and minor sections the junction area usually presents the greatest straightening problems. Typical junction area tolerances and their application are shown in Fig. 4.

In the design of stepped extrusions, produced from split dies, parting line locations should be considered not only from the tolerance standpoint, but from the ability to remove tools from the section. In some cases it may be necessary to provide slight draft angles on extended elements to accomplish this. While the major and minor sections may frequently have a common plane, this is not a requirement of the process. In all cases the major section must completely enclose the minor.

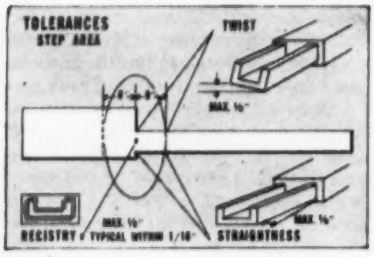


Figure 4

Cross sectional tolerances of stepped extrusions are usually greater than normal due to the inherent instability of split dies. It is generally necessary to provide sufficient machining stock on all surfaces of the section to be able to obtain the required accuracy of dimension and surface finish requirements. This is particularly true regarding dimensions which fall across the parting lines of the die. An additional tolerance is usually required on these dimensions due to possible shifting of the die segment. Fig. 5.

With the abrupt change in flow pattern between the minor and major sections, areas of reduced mechanical properties are sometimes encountered at the junction extremities of the major section. This condition is illustrated by the flow patterns shown in Fig. 6.

In each case the so-called dead metal

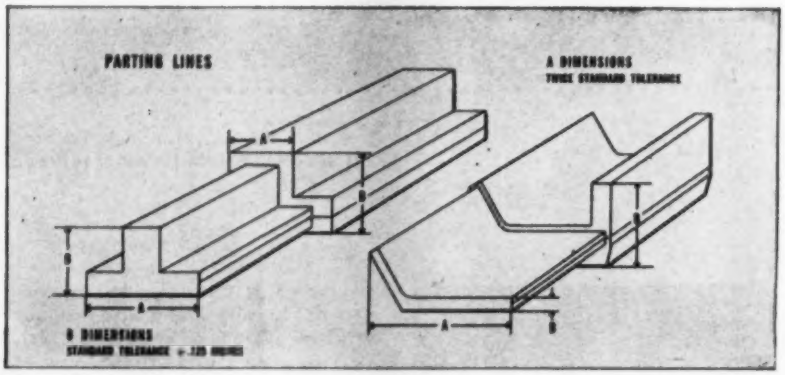


Figure 5

areas not included in the direct flow path would be removed by following recommended machining practices shown in Fig. 7.

An additional consideration which must be recognized is the cross-sectional areas of major and minor sections and the ratio of major area to minor area. These will have a marked influence on the mechanical properties obtainable. In normal aluminum extrusions, mechanical properties are dependent on the degree of working the cast ingot received as measured by the reduction ratio. The reduction ratio is the ratio of extrusion press container area to the area of the part being extruded. Substandard mechanical properties are obtained in 7075 aluminum alloy when reduction ratios less than about 6:1 are used. When reduction ratios greater than about 30:1 are used for 7075 alloy, excessive pressures are required.

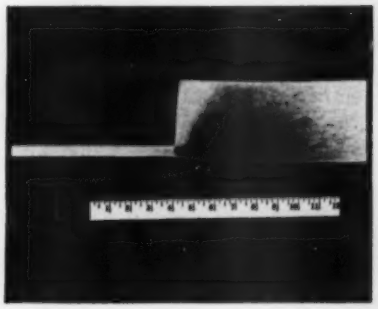


Figure 6

The designer usually had no knowledge or control of the container size on which a part is to be produced. In order to make the section producible under optimum conditions, the major area to minor area ratio should not exceed 5:1.

The mechanical properties of stepped extrusions, particularly the junction area, have been the subject of many discussions. In some cases, due to the differences in areas and thicknesses it will be necessary to work to two sets of allowable design stresses in the major

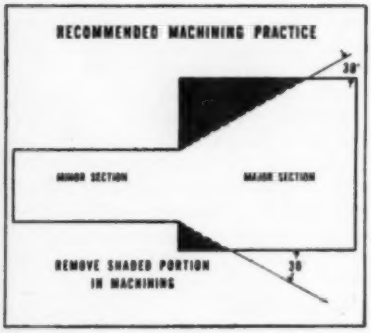


Figure 7

and minor parts of the extrusion. As the producer cannot vary extrusion temperatures rapidly enough to create ideal conditions for both major and minor sections, it is necessary to use a compromise for the extrusion of both parts.

For example, it may be necessary to use an elevated extrusion temperature to start the minor section moving through the die. After the dies are changed to produce the major section this temperature may be considerably in excess of that required. From the standpoint of pressure requirements the major section has the advantage of a lower reduction ratio and the reduced billet length resulting from extrusion of the minor part. Mechanical properties for typical 7075-T6 aluminum alloy stepped extrusions are shown in Table 1 (last page). In most cases it will be

(Advertisement)

noted that the strength levels in the minor section are slightly greater than in the major, with the junction properties being equal to or slightly lower than in the major section. The effect of higher than recommended major to minor area ratios will be noted in section D where the ratio is 8.9:1. In this case the strength levels in the lower section are considerably below those of the minor section in both longitudinal and transverse directions, with the junction properties falling below those of the major sections. Investigations have been made to determine mechanical property levels along a specific line from the front to the back of the extrusion. Results of a typical study are shown in Fig. 8. Mechanical properties are fairly uniform along the length of the part following the general trend indicated above. The lowest mechanical properties are above the specification minima in all parts of the extrusion.

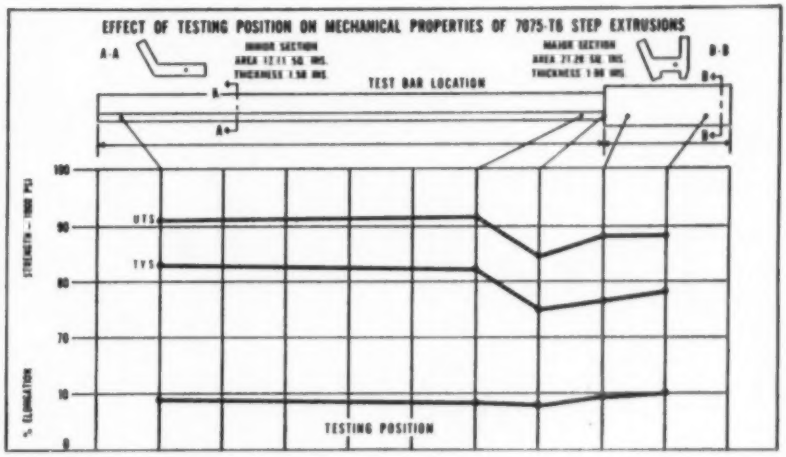


Figure 8

Finishing operations for step extrusions follow, in general, the practices used for normal products. A typical sequence of operations for 7075 aluminum alloy step extrusions would be as follows:

(a) Extrude
(b) Solution heat treat
(c) Stretch straighten
(d) Cut to length
(e) Age

In the solution heat treating operations, time at temperature would be determined by the thickest element of the major section which would probably be slightly longer than the time required for the minor section alone. The normal practice in stretching is to grip each end of the section in a hydraulic unit and exert the necessary stretching force to straighten the part. Due to the difference in area, all of the permanent set in stretching is obtained in the minor section. It may be necessary in some cases to carry out straightening operations on the major section and step area on a gag press. These operations would be performed before solution heat treatment wherever possible to avoid leaving residual stresses.

As all step extrusions are machined to varying degrees the problems of warpage following machining are frequently encountered. This is very likely aggravated by differential residual stress patterns in the minor and major sections of the extrusion. Experience on plate has indicated that a 2% permanent set stretch will virtually eliminate warpage which occurs following machining operations. Experience on extrusions indicates similar results may be achieved by stretching. The optimum amount of stretching required on extrusions has not been clearly established. A possible approach to this problem would be the addition of finishing operations in the sequence shown in Fig. 9. The additional stretching and machining operations would result in a part uniformly stretched throughout the length. Work on this process is still in the development stages. It is not yet possible to predict whether this method will be successful in reducing warpage following machining or whether the improvement will be sufficient to justify the additional costs.

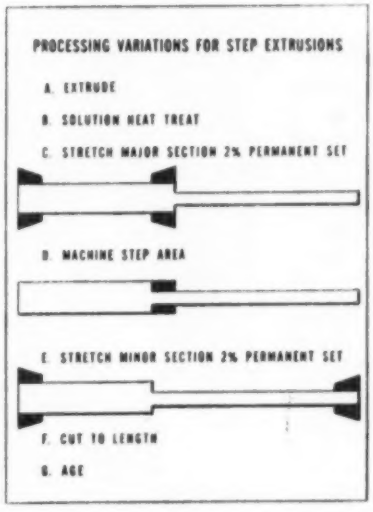

PROCESSING VARIATIONS FOR STEP EXTRUSIONS
A. EXTRUDE
B. SOLUTION HEAT TREAT
C. STRETCH MAJOR SECTION 2% PERMANENT SET
D. MACHINE STEP AREA
E. STRETCH MINOR SECTION 2% PERMANENT SET
F. CUT TO LENGTH
G. AGE

Figure 9

In considering other new developments in the step extrusion field it has long been considered a possibility to produce parts with two, three or more steps. In these cases, rather than two sets of dies, three or more sets would be used to produce the desired configurations. This, of course, would introduce additional operations in producing a given part with increased tooling costs which would add to the price of the section. In most cases it has appeared difficult to economically justify additional steps.

Extrusion technology has advanced very rapidly in the past several years, making it difficult to predict line of future growth. The present day producer many times finds himself producing products which a few years ago may have been considered impossible or impractical. A possible step extrusion which might be produced in the future would be an extrusion with a major section on both ends, such as shown in Fig. 10A. (next page). This would allow an integral fitting to be used on both extremities of the part. With the advancement of extrusion technology, this appears possible and may become commonplace in the future. Many of the present step extrusions are used for aircraft spar cap application. Requirements for step extrusions can be visualized with the major portion being located in the center of the part as shown in Fig. 10B (next page). It would seem that extrusions of this type could be ideally used for aircraft stabilizer spar caps extending completely through the fuselage or for similar applications on the wing. In some cases this enlarged portion could be used for attachment

(Advertisement)

points for the landing gear. While seemingly far-fetched, these products are not impossible from the extrusion producers' standpoint although it would be emphasized that a great deal of time and development effort would be required to make these products a production reality.

Many applications for large tubular parts are being developed in the missile field. Internal and external steps on these tubes can be obtained through the use of a stepped mandrel combined with the techniques normally used to produce step extrusions. The use of a stepped mandrel has previously had the limitations of allowing only unidirectional stepping of the interior surface. With modern extrusion equipment it is possible to place these steps at either end of the tube or in the center, as desired. Typical of a product that could be produced by this means is the part shown in Fig. 10C.

MECHANICAL PROPERTIES OF 7075-T6 ALUMINUM ALLOY STEP EXTRUSIONS

	MAJOR PART						JUNCTION			MINOR PART					
	Thickness	Area	Testing Direction	1000 PSI TS	1000 PSI TYS	%E	1000 PSI TS	1000 PSI TYS	%E	Thickness	Area	Testing Direction	1000 PSI TS	1000 PSI TYS	%E
Extrusion A	1.70	8.80	L	88.4	83.2	8.0	89.9	81.6	9.0	.88	4.42	L	90.3	84.2	9.1
Extrusion B	3.66	16.86	L	88.4	82.1	8.0				.72	5.98	L	90.2	84.8	10.0
Extrusion C	2.23	17.29	L	86.7	81.9	8.9	87.3	80.3	6.0	1.10	5.36	L	87.0	79.9	10.1
Extrusion D	1.58	21.20	L	88.8	81.2	10.2	86.9	76.8	9.5	1.58	12.11	L	91.6	83.4	9.2
			T	80.1	71.7	6.6						T	84.7	72.5	8.0
Extrusion E	4.66	29.95	L	86.6	81.2	11.0				1.40	10.63	L	91.0	84.4	9.0
			T	71.2	66.0	4.6									
Extrusion F	5.32	29.32	L	88.2	75.0	9.0	79.5	71.0	4.0	.485	3.30	L	98.4	84.3	12.0
			T	71.0	56.0	4.7						T	77.6	72.4	4.0
Specification Minimum Values															
	Up thru .249	All	L	78.0	70.0	7.0									
	.250-2.999	All	L	80.0	72.0	7.0									
	3.000-4.499	Up thru 20	L	80.0	70.0	7.0									
	3.000-4.499	Over 20 Thru 32	L	78.0	70.0	6.0									
	4.500-5.000	Up thru 32	L	78.0	68.0	6.0									

Table 1

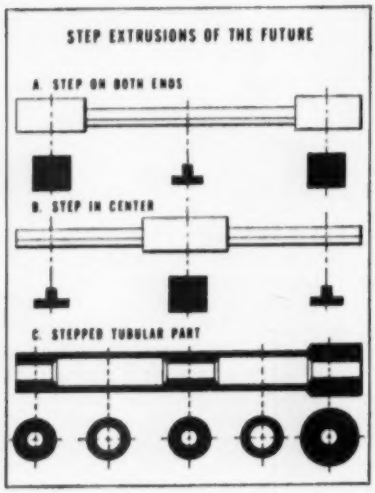


Figure 10

In other areas of development of extruded products for aircraft usage, integrally stiffened panels are now becoming commonplace. These products are presently available in widths up to 25" extruded in flat configuration. Development work indicates greater widths are available from existing equipment. Frequently this type of section will be extruded in a "V" or tubular configuration to obtain greater widths. A great deal of effort has been expended in attempting to flatten tubular extrusions to obtain the desired flatness required of aerodynamic surfaces. The success of this work has been limited, hence, the uses of this product have been principally in interior applications. With the amount of development effort being expended in this area, it seems very likely the problem of flattening tubular extrusions will soon become a thing of the past.

The extrusion of tubular parts with external or internal rifling has been carried on for some time. These techniques have been developed to a point where it is possible to maintain very close tolerances on the degree of spiral. Parts such as these have found application in the missile field.

Looking to the future on the uses of extrusions in the aircraft industry, it seems that a new family of products will be produced within the next few years. With the full scale production from the Air Force Heavy Press program, very likely larger and longer extrusions will be commonplace. Drastic improvements in the quality levels of aluminum products have been achieved through new melting and casting techniques, resulting in improved metal quality. Immersion ultrasonic testing techniques are becoming more advanced daily, with rigid standards being established to meet the aircraft industry's exacting requirements. With the new demands industry is placing on the extrusion process it is assured of continued growth into bigger and wider fields of application.

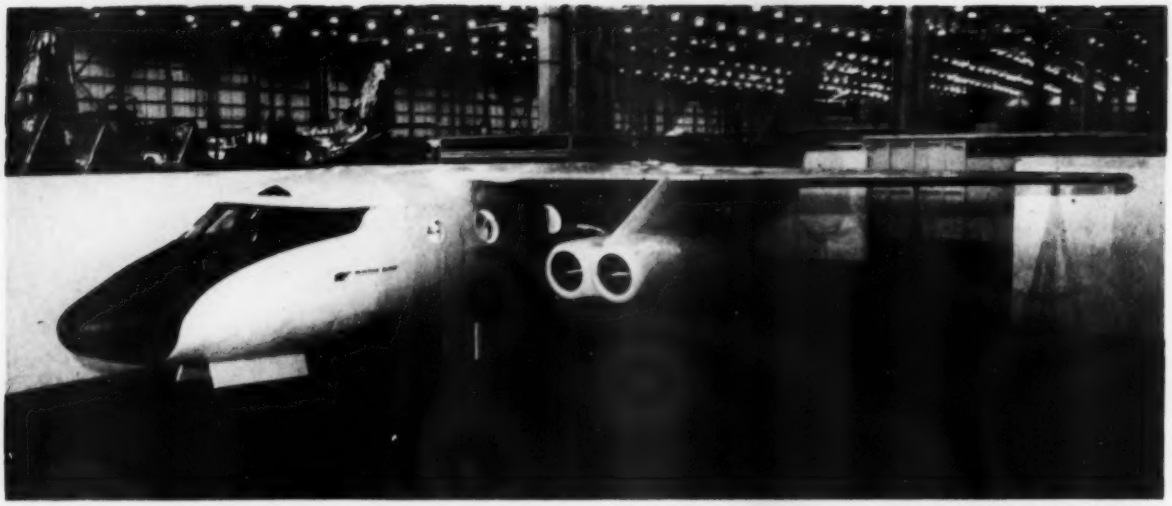
For immediate attention to any extrusion request, contact the Kaiser Aluminum sales office or distributor listed in your classified telephone directory. Kaiser Aluminum & Chemical Sales, Inc., *General Sales Office,* Palmolive Bldg., Chicago 11, Illinois; *Executive Office,* Kaiser Bldg., Oakland 12, California.

Free reprints of this advertisement are available upon request. Write to Kaiser Aluminum & Chemical Corporation, 1924 Broadway, Oakland 12, California.

Panel presentation made at Aircraft Production Forum of the Society of Automotive Engineers at Los Angeles, October 3, 1956.

Kaiser Aluminum

Expanding business plane production offers new power, performance to suit every requirement



FAIRCHILD M-185 MOCKUP

Business Flying Shows Sharp Upswing

By Erwin J. Bulban

New York—Business flying is well on the way to casting off last shackles of obsolescence and achieving its long dream of a fleet of modern aircraft in all categories. Growing interest in turbine-powered equipment, substantiated with contracts, is bringing business flyers closer to their more sophisticated brothers in the military service and the airlines.

Tied to obsolete aircraft for the better part of a decade, during which business flying nevertheless achieved amazing growth, business flyers find this new equipment promises them an era of even greater expansion.

An increase in business flying to over 9.9 million hours and more than 1.8 billion miles in 1970 is forecast by the Civil Aeronautics Administration's Office of Planning, Research & Development.

A gage of this growth is provided by current figures. Last year business pilots flew 4.5 million hours—more than all of the U. S. scheduled airlines put together. Next year they are expected to top 4.8 million hours. Currently they are flying almost as many hours as all other segments of general aviation, which embraces all civil aircraft activities except airlines.

Start on Turbine Fleet

Most significant new equipment purchase last year was a commitment by Gen. Lucius D. Clay, board chairman of Continental Can Co., for three four-jet Fairchild M-185F executive transports to be delivered starting in 1960. This was followed by an order for another M-185F by Continental Oil Co. Continental Can in addition has a Fairchild F-27 Friendship twin-turboprop executive plane due for delivery in July 1958.

Definite commitments have been made by a number of other corporations.

Businessmen will be flying their own turbine-powered planes before either of the Fairchild models is delivered. U. S. Steel executives this year will utilize three turboprop-powered special Vickers Viscounts, which are currently having custom interiors installed at L. B. Smith Aircraft's large Miami modification base. Delivery began late last year. These first turbine-powered business transports will be flown and maintained by Capital Airlines. Additional Viscounts are on the way for Howard Hughes and Standard Oil of California.

Although off to a slow start, interest in these new jet and turboprop aircraft is accelerating. Numerous corporations have sent their pilots and evaluation personnel to Holland to fly the prototype turboprop Friendship, an experience that reportedly has been pleasantly surprising. Ranking particularly high are relatively simple cockpit operation, fast acceleration, short takeoff and good single-engine performance. Companies are also visiting Hagerstown, Md., to study the M-185 full-size mockup. Fairchild says that the jet's price will not exceed $800,000, minus cabin interior and plug-in radio.

Interest in jets, continuing to build during the past year at business flying conventions and forums, received its biggest boost to date when the U. S. Air Force and the National Business Aircraft Assn. jointly sponsored a two-day program at Wright-Patterson AFB, Ohio, early this month to brief executive pilots on jet aircraft operations, maintenance and navigation.

Also significant last year was the start of an extensive flight test program on the new Cessna 620, an eleven-place four-engine transport—first pressurized aircraft expressly designed for corporation use. Aimed at providing for the modern requirements of corporations now flying prewar Lockheed Lodestars and Douglas DC-3s, the 620 is especially designed for high-altitude operations and self-sufficiency for off-airways operations. An AiResearch gas turbine auxiliary powerplant not only supplies pressurization but also air conditions the interior and provides a source of electrical power to make the airplane independent of ground equipment.

The 280-mph. 620 will be available late in 1958 at a price of approximately $375,000.

Up-to-Date Equipment

This tangible progress, plus additional multi-jet designs in the mill at North American and Lockheed, are evidence that the industry, long under fire from business plane operators to develop up-to-date equipment, is at last actually working to complete the spectrum of new executive planes that faded beyond the light twin class.

Market for new four-place and larger business aircraft last year broke all

AERO COMMANDER SUPER 680

previous records, the industry delivering more than 6,800 aircraft having a net billing value to the factories of more than $103.7 million. This compared to 4,435 units in 1955 having a value of approximately $91 million. It marked another year of increased production of twin-engine aircraft, over 1,000 being delivered, compared with 800 in 1955.

New highs were reached by the industry's "big three," Beech, Cessna and Piper:

• **Beech fiscal 1956** sales went up 23% over the previous year to total $32,091,761, close to its military sales volume of $42,447,187.

• **Cessna led** the industry with business aircraft sales totaling $37,703,472, a 33% increase over 1955. Military volume totaled $24,526,365.

• **Piper's commercial sales** jumped nearly 50% for a volume of $23,218,398; military sales, which this company does not push, were a negligible $1,865,307.

• **Aero Design** is cautious about revealing its sales activities, but last year it delivered more than 150 twin-engine Commanders.

In all, these four leading business plane manufacturers turned out more than 6,400 units having a total retail value exceeding $128 million.

A bigger year is forecast for 1957: Beech predicts commercial sales of $46 million this year. Piper has set $36 million as its target. Only Cessna does not foresee a big jump in sales.

This is probably due in part to the major production effort the company made last year when it outproduced the other three top companies combined by more than 1,000 units.

This year Piper will come out with the first of two models of its low-wing four-place Comanche, aimed primarily at the 182 market. Beech will offer its new light twin Model 95 Travel Air to compete in price with the Cessna 310.

New entries in the industry showed strength last year, particularly Champion Aircraft, which is now building the former Aeronca Champion 7EC. Champion delivered 215 7ECs in 1956.

U. S. CIVIL AIRCRAFT BY MANUFACTURER

(as of January 1, 1956)

Manufacturer	Number of Aircraft			Percent of U. S. Total		
	Active	Inactive	Total	Active	Inactive	Total
Piper	14,466	5,653	20,119	23 9	22 7	23 6
Cessna	11,293	2,261	13,554	18 7	9 1	15 9
Aeronca	5,825	3,142	8,967	9 6	12 6	10 5
Beech	4,501	498	4,999	7 5	2 0	5 8
Convair-Stinson	4,268	2,614	6,882	7 1	10 5	8 1
Luscombe	2,978	993	3,971	4 9	4 0	4 6
Taylorcraft	2,960	2,070	5,030	4 9	8 3	5 9
Ercoupe	2,706	852	3,558	4 5	3 4	4 2
Boeing-Stearman	2,196	1,293	3,489	3 6	5 2	4 1
Fairchild	832	1,318	2,150	1 4	5 3	2 5
All others	8,407	4,194	12,601	13 9	16 9	14 8
Totals	60,432	24,888	85,320	100 0	100 0	100 0

Source: CAA Statistical Study of U. S. Civil Aircraft.

This latest study is of particular interest statistically, since it reflects a year-long campaign against "deadwood" in CAA's aircraft registration files. As a result, the number of registered civil aircraft dropped from 92,067 as of Jan. 1, 1955 to 85,320 in the above official report. However, in the same period, the number of active aircraft climbed from 58,994 to 60,432. The "anti-deadwood" campaign reduced inactive registrations from 33,073 or 36% of the total to 24,888, only 29%. When the campaign is complete, CAA estimates another 4,000 registrations will be canceled.

U. S. Business & Utility Aircraft Shipments—1956

(Number of Units, Builders' Net Billing Prices)

Make & Model	January	February	March	April	May	June	July
AERO DESIGN 560-A	9	7	4	7	3	2	4
680	0	0	4	5	9	12	14
	$670,560	$417,200	$652,000	$990,000	$964,000	$983,000	$1,180,000
BEECH 35	37	47	46	46	44	46	35
E18S	6	7	8	11	13	8	10
D18S	0	0	2	1	3	0	0
50	8	13	12	12	12	10	15
40	0	0	0	5	0	0	0
	$1,807,800	2,425,836	2,556,212	3,043,118	3,116,443	2,489,662	2,589,200
CALL A-4	0	2	1	1	3	2	2
Super Cadet	0	0	0	0	0	0	0
	0	11,008	7,000	5,116	15,497	10,991	11,106
CESSNA 170	20	6	6	11	18	4	6
172	132	150	148	103	110	111	105
180	79	106	63	39	34	28	22
182	0	0	76	127	148	134	113
310	21	22	21	20	22	16	16
	$3,735,600	2,962,307	3,611,878	3,713,519	3,984,893	3,464,220	3,063,581
CHAMPION 7EC	12	12	14	17	23	19	19
	$60,600	53,000	66,000	86,037	77,941	70,800	70,350
COLONIAL C-1	0	0	0	0	0	0	0
	0	0	0	0	0	0	0
HELIO H-391B	3	2	2	2	3	2	3
	$69,000	46,000	46,000	46,000	69,000	46,000	69,000
MOONEY MK. 20	5	1	7	2	9	8	6
MK. 16	0	0	3	3	1	0	2
	$60,137	11,402	79,451	30,253	93,629	79,000	65,733
PIPER PA-18	19	20	18	18	22	14	19
PA-18A	38	51	46	54	52	45	19
PA-22	105	104	94	130	121	104	53
PA-23	22	30	34	38	41	37	21
	$1,815,474	2,081,916	1,583,948	2,196,229	2,265,269	2,016,462	1,068,295
TAYLORCRAFT MODEL 20	3	1	4	3	4	4	4
	$27,567	9,585	36,000	27,000	40,000	20,000	39,600
TRECKER P.136L.1	2	2	2	1	0	1	2
	$149,000	149,000	149,000	74,500	0	74,500	149,000
TOTALS (Aircraft)	527	501	617	654	593	511	489
TOTALS (Net Billing Price)	$8,384,378	$8,136,514	$9,067,489	$10,063,769	$10,646,672	$9,264,585	$8,343,067

Source: Manufacturers reports to AVIATION WEEK. In addition to standard line, Cessna delivered following: 1 Model 325 agricultural aircraft (modified L-19) in March; 5 Model 195 and 1 Model 325 in April; 1 Model 195 in Sept. Dollar volumes included in monthly data above.

BEECH BONANZA

is offering a tricycle-geared model this year. Trecker (formerly Royal Aircraft) delivered 13 Royal Gull twin-engine amphibians and is now offering the plane with 340-hp. supercharged engines. Colonial Aircraft started deliveries of its single-engine Skimmer amphibian in August, has delivered 11 planes since. Helio has delivered approximately 30 short-takeoff Couriers.

Who Buys

Where are these airplanes going? A Cessna sales survey of its customers for December 1955 through September 1956 showed these percentages by industry classification (light twin sales in parentheses): Business services, 4.9 (9.2); personal services, including professional people, 12.4 (1.5); manufacturing, 14.3 (24.6); wholesalers, 7.3 (6.2); retailers, 7.0 (4.6); transportation, 3.6 (4.6); communications, 1.6; government, 1.3 (1.5); public utilities, 0.3; construction, 14.6 (9.2); agriculture, forestry, fisheries, 11.3 (6.2); mining and oil, 15.8 (24.6); finance, insurance, real estate, 5.6 (7.8).

More power and speed continues to

August	September	October	November	December	Totals
4 14 $1,186,000	5 10 $975,000	2 18 $1,546,000	2 16 $873,000	1 7 $586,000	80 111 $10,960,700
43 10 0 11 0 2,560,749	27 9 0 12 45 2,535,260	34 9 0 5 0 1,814,068	16 11 0 3 10 1,947,836	37 7 0 6 0 1,685,883	480 109 6 119 86 $29,771,044
2 0 11,000	2 0 11,000	0 0 0	2 1 16,118	1 0 5,643	18 1 $106,481
0 106 61 84 27 3,633,384	1 228 21 45 15 2,472,440	1 97 20 63 17 2,745,226	0 89 16 30 12 1,829,828	0 40 47 143 12 3,119,388	72 1,419 530 983 223 $30,325,264
21 87,875	18 88,900	21 90,300	22 91,600	17 77,400	215 $867,403
2 34,000	2 34,000	2 34,000	2 34,000	3 57,000	11 $193,000
2 46,000	2 46,000	2 46,000	2 46,000	2 46,000	27 $621,000
8 0 82,000	9 0 93,400	5 0 52,000	5 0 51,000	5 0 51,833	70 9 $742,538
27 34 117 57 2,899,380	61 31 72 34 1,982,000	17 28 71 31 1,548,524	12 19 99 38 2,095,994	86 11 93 39 2,211,832	332 428 1,163 439 $23,446,013
4 38,000	4 38,000	2 20,961	4 38,000	4 23,799	41 $356,712
2 149,000	0 0	1 74,500	0 0	0 0	13 $968,500
536 $10,425,058	552 $7,956,000	466 $7,971,579	417 $7,025,376	560 $8,063,158	5,914 $106,357,655

be the trend, with the supercharged light engine gaining increasing favor for the extra performance it gives, particularly at altitudes over 10,000 ft. Because of increasing fleet of bigger and faster aircraft, employment of professional pilots is also gaining. More than 3,500 business aircraft are flown by professionals, according to CAA; most multi-engine aircraft owners employ their services while only one in 10 of the single-engine class is flown by a professional.

Also noteworthy is the higher utilization of the bigger airplane; CAA indicates that generally multi-engine aircraft spend about twice the hours aloft as the average single-engine types.

Data on the number of business aircraft in service is still difficult to obtain. CAA only last July began to ask owners of general aviation category aircraft to indicate primary usage.

Last estimates were that approximately 36,000 aircraft did some business flying in 1955; of these 18-19,000 were primarily used for this purpose.

Current estimates of the number of multi-engine business planes in service add to about 3,500.

How did business aircraft fare in accident rates last year? CAA safety personnel are inclined to believe that their record was a good one. The count: approximately 36 accidents involving multi-engine aircraft under 12,500 lb. gross weight, six over that weight.

The smaller aircraft accounted for nine fatalities (including two persons on the ground) and eight injuries; data on the bigger planes is still being compiled.

The breakdown by type, according to CAA's files: Aero Commander, 5; Beech 18, 12; Cessna 310, 7; DH Doves, 2; Grumman Goose, 2; Grumman Widgeon, 2; Lockheed 12-A, 2; Piper Apache, 2; Riley Twin-Navion, 1 and Trecker Royal Gull, 1. In the over 12,500-lb. gross weight class two were Lockheed Lodestars and three Lockheed Venturas.

Good as the record might be, CAA safety people are not complacent about it and the indications are that they are actively considering new rulings that they feel will improve the record or prevent it from deteriorating.

One of the proposals that is discussed most frequently is that pilots of light twins be type certificated for each model airplane, much as is required by pilots of the 12,500-lb. and over category.

Another item under consideration is a regulation governing the number of hours business pilots can fly within a specified period of time.

Field Agents Trained

CAA is currently training field agents in the problems and operations of business flying to develop personnel along the lines of bank examiners who will do routine checks on executive plane operators in their areas.

As regards equipment, many business planes are better fitted than airliners; and of the total amount of weather radar, autopilots and omni-range gear in all U. S. civil aircraft, they carry the majority. Manufacturers are hard at work developing equipment particularly suited in size and weight for these airplanes. Lightweight weather radars suitable for the small twins, simplified low-cost autopilots for single-engine types and larger are examples.

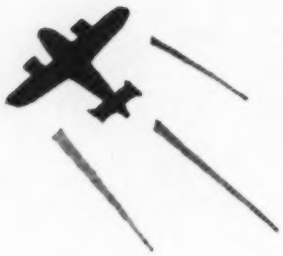
The equipment market is indicated by comparing manufacturers' list prices for the standard versions of their models with that of the average airplanes delivered to customer specifications regarding extra equipment, list prices in parentheses: Beech 35 Bonanza, approximately $25,000 ($22,650); Beech E50 Twin-Bonanza, $100,000 ($88,000); Beech E18s, $130,000 ($106,975). Last year Cessna's Model 172 listed for $8,750. As delivered to the dealer for his customer this airplane was price tagged at about $9,550. Some 70% of the Model 310s leaving Wichita last year carried $20,000 worth of optional equipment.

Service Facilities Grow

Expansion of servicing facilities to handle this rapidly growing fleet of constantly moving aircraft is expected to be aided considerably by Small Business Administration's announcement last year that Federal loans will be made to finance hangar and shop building.

Effective augmentation of this program will in turn encourage more business firms to operate aircraft. There are many who hold back, pending availability of facilities to care properly for their planes. In the case of operators, there are some who have seen planes based at their fields go hundreds of miles away for maintenance because they were unable to secure necessary bank loans to expand facilities.

Estimate that there is a current need for approximately $90 million worth of new hangar and shop construction has



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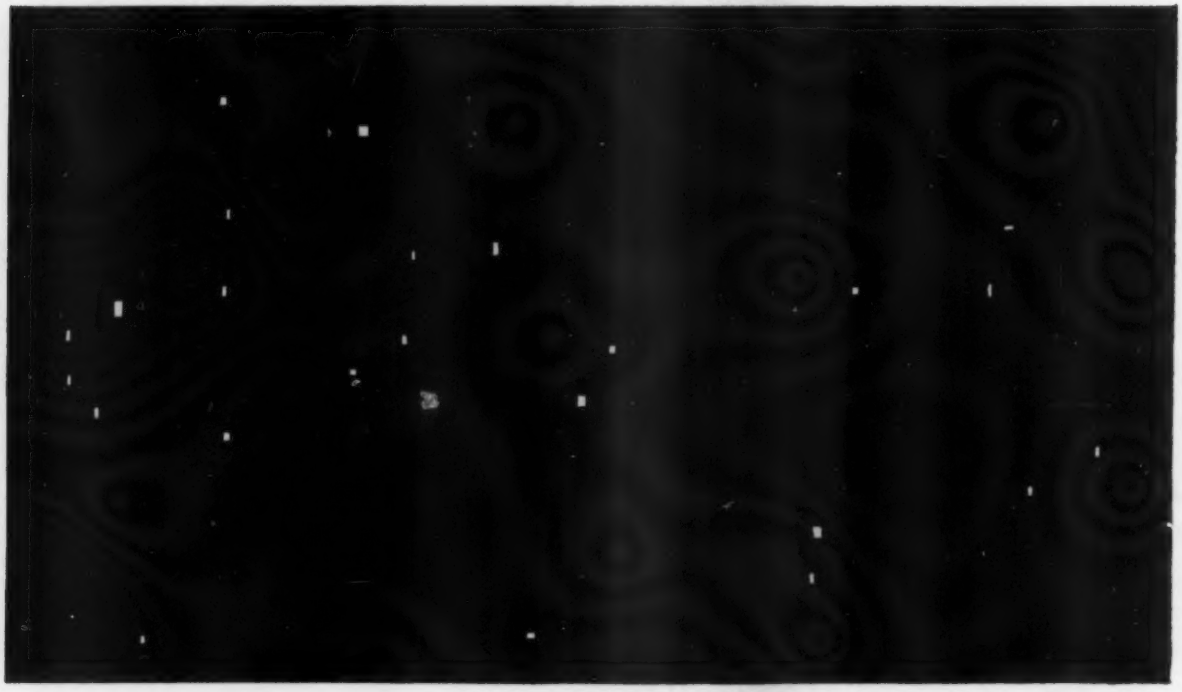

been made by J. B. Hartranft, Jr., president, Aircraft Owners & Pilots Assn. Aside from this immediate need, he sees an additional $10 million expenditure required annually to keep pace with the growing civil air fleet.

General aviation alone is expected to be operating 69,500 active aircraft by 1960, 89,000 by 1965 and 107,875 by 1975, CAA planning experts report.

Preparation for this potential already is underway at key areas of the country. Southwest Airmotive expects to have the major portion of a $4 million construction program completed by the end of this year at Love Field, Dallas, Tex.

It has borrowed $1.5 million from the city's airport bond funds, will finance the remainder privately.

A look at its business record last year shows the reason for this optimism; in 1956 Southwest took care of 14,400 visiting planes. Of these, 9,900 were business planes, 3,300 were military piston and jet-powered types and 1,200 were non-scheduled airliners.

Another large operator, occupying a new $1 million business aircraft service center at O'Hare Field-Chicago International Airport, is John P. Henebry's Skymotive, Inc., which handled approximately 1,200 airplanes in 1956, supplying 621,872 gal. of gasoline to these customers. Henebry estimates that there are approximately 125 business planes located in the Chicago area; his base has 32 as tenants.

BUSINESS FLYING 1946-1970

	Hours (000's Omitted)	Miles (000's Omitted)
1946	1,068	121,530
1947	1,966	228,125
1948	2,576	298,945
1949	2,615	309,062
1950[1]	2,750	339,700
1951	2,950	379,845
1952	3,124	419,705
1953	3,626	499,166
1954	3,875	552,610
1955[2]	4,300	614,900
1956[2]	4,580	691,420
1960[3]	5,700	997,500
1965[3]	7,807	1,483,300
1970[3]		
Low	9,000	1,710,000
Intermediate	9,929	1,886,500
High	11,000	2,090,000

Sources: 1946-1954, CAA Annual Survey of Aircraft Use; 1955-1970 CAA Program Planning Office.

1. Data statistically computed from trend since no formal survey made by CAA in 1950.
2. Based on preliminary data.
3. Estimates.

Apart from the sophisticated fixed base operators, who have learned to grow with this new business, there are many who still treat it casually, to the frustration of many executive plane pilots who too often touch down for refueling or refreshment and then have to literally hunt down personnel to provide them with the service they need. It doesn't happen too often to the same pilot, if he can help it. He will go many miles out of his way to give his business, including the purchase of hundreds of gallons of fuel, to a businesslike operation where there are neat linemen to guide him to the ramp, take his order, help him disembark his passengers and round up necessary transportation or even hotel accommodations.

Developing a skilled staff, a good echelon of supervisory personnel and also learning the ins-and-outs of good financing are among the necessary requisites of the new breed of fixed base operator.

Some are lulled into complacency because they feel they have adequate facilities and can point to a tenant list —but it may be that the latter is partly due to overcrowding elsewhere. Should a competitor expand facilities, the complacent operator may find business going off quickly.

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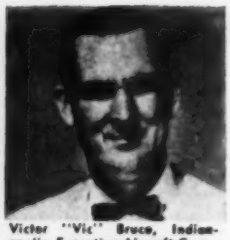
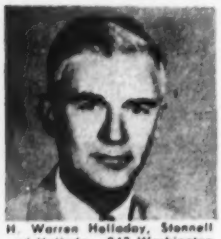
Peter Graves, Southern Ohio Aviation Sales Co., Dayton Municipal Airport, Vandalia, Ohio.

John Wiladon, Hunter Aviation Co., P. O. Box 122, Lambert Field, St. Louis, Missouri.



Victor "Vic" Bruce, Indianapolis Executive Aircraft Corp., Indianapolis Municipal Airport, Indianapolis, Indiana.



H. Warren Holladay, Stonnell and Holladay, 843 Washington Building, Arlington Towers, Arlington, Virginia

A. M. "Sime" Bertolet, Reading Aviation Service, Inc., Municipal Airport, Reading, Pennsylvania.

H. Leibee Wheeler, Buffalo Aeronautical Corporation, Buffalo Municipal Airport, Buffalo, New York.

John S. Brown, Brown Aero Corp., 3300 Love Field Drive, Dallas, Texas.

Robert F. Wood, Newport Air Park, Newport, Rhode Island.

Wynn Cronje, Minnesota Airmotive, Inc., Minneapolis-St. Paul International Airport, Minneapolis, Minnesota.

Norman Hoffman, West Texas Flying Service, Midland Airport, Box 82, Midland, Texas.

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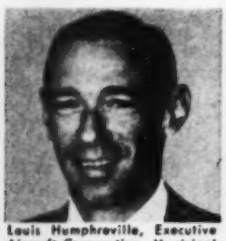
W. D. Maddox, Aero Southern Corp., 601 North Broadway, Nashville, Tennessee

W. H. "Bill" Buchanan, Sales Manager, Johnson Air Interests, Inc., Horlick-Racine Airport, Racine, Wisconsin.



Louis Humphreville, Executive Aircraft Corporation, Municipal Airport, Pontiac, Michigan.

O. B. Catlin, Fairfax Aviation, Inc., 3301 Fairfax Trafficway, Fairfax Airport, Kansas City, Kansas.

John A. "Jack" Bauman, Santa Monica Aviation, 3011 Airport Avenue, Municipal Airport, Santa Monica, California.

Harrel Bellamy, L. B. Smith Aircraft Corp., Miami International Airport, Miami, Florida.

Lucien M. Tellier, Trans-Aire Corporation, Pan-Air Building, New Orleans Airport, New Orleans, Louisiana

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Although the data on 1956 agricultural aviation operations was not fully collated by early this year, the trend indicates that it probably exceeded 1955, a record year for the aerial applicator.

One signpost of the trend is that last year aerial operations against insects under State-U. S. Department of Agriculture contracts were the most extensive in history.

Total Acreage

Aircraft operating under State and Federal contracts in 1956 sprayed and dusted insecticides on more than 5 million acres throughout the U. S.—9 million acres, counting treatments in the large-scale war against the Mediterranean fruit fly. The growth of these contract operations in recent years can be appraised from these official data: 1950, 4.2 million acres; 1951, 1.9 million acres; 1952, 1.5 million acres; 1953, 1.4 million acres; 1954, 2.5 million acres and 1955, 4.2 million acres.

These figures do not include the vast areas covered by aerial applicators for farmers and ranchers, since these figures are late in being compiled. But the total activity in 1955 accounted for over 60.1 million acres and it is expected that 1956 private operations went as least as well.

Breakdown of the various 1956 State-USDA contracted operations against insects:

- **Grasshopper control** programs covered 2 million acres of ranchland aerially in 10 western states.
- **Spruce budworm control** accounted for about 1.4 million acres in Montana and Idaho.
- **Mediterranean fruit fly** treatment required 4.5 million acres of spray treatments over a three-quarter million acre area in Florida.
- **Gypsy moth control** covered about 1 million acres of forests in eight northeastern states and Michigan.

Combined Programs

In addition, there were important programs with federal-state funds involving 58,000 acres in five western states on Mormon crickets, 12,000 acres covered in Idaho against the beet-leafhopper, 10,000 acres in three states against the tussock moth and 3,000 acres covered in Wisconsin and Michigan on spittlebug control.

Big programs appear to be slated for USDA and the states. One of the largest will be a six-weeks attack on the gypsy moth beginning this May covering New Jersey, Pennsylvania and most of upper New York from border to border. It will probably necessitate covering 2-4 million acres annually for three years.

Under consideration is night spraying from 500 to 1,500-ft. altitudes, probably the first time this would be done. Some western operators have worked aerially at night on cotton, but at much lower altitudes because of less rugged terrain.

Growing ever larger, these vast application programs are encouraging a trend towards larger aircraft through the four-engine B-17. In 1955 there were 18 big ships, including C-46, C-82, the Flying Fortress, and DC-3, used by operators on this type of contract.

Last year the number had just about doubled, and the outlook is that it will continue to rise.

Another factor encouraging the use

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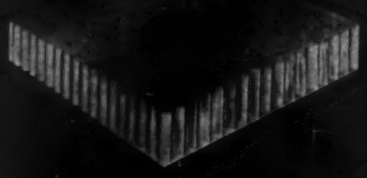

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of multi-engine types is increased activity over populated areas. In 1955 approximately 1.5 million acres of congested area application was done.

This involved 10,500 flying hours during which 218,000 lb. of dry chemicals and 2 million gal. of spray were applied.

According to the Civil Aeronautics Administration, the figures for 1956 will be much higher. CAA people feel that multi-engine aircraft provide a much higher safety factor in event of engine failure than smaller ships.

Safety Measures

Congested area work is also the subject of some CAA thinking about revising regulations to enhance safety. Under consideration are requirements that operators have emergency dump valves for rapid jettisoning of material in event of engine failure, improved plotting of operations to insure that clear areas for emergency landings are usually available, and two-way radio, particularly in areas where air traffic is a factor.

Increase in pleasure flying the last few years, mainly due to use of business aircraft operated by individuals on weekends and vacations, is expected to continue its gradual upswing from approximately 2 million hours annually to 2.3 million hours a year in 1960 and 3.4 million hours by 1970.

Unfortunately for many enthusiasts unable to justify an airplane for business as well as pleasure, circumstances continue to work against them unless they are financially able to afford modern equipment. The ever-tightening traffic control picture, increasing requirement for two-way radio, gobbling up of former small airfields by real estate operators, all tend to make their flight path difficult.

Aging Equipment

None of the major manufacturers is developing any new hardware for them, so as in past years their equipment continued to age.

Instructional flying, accounting for approximately 1.3 million hours of annual general aviation activity, is certain to expand gradually in the next few years, CAA forecasters say, reaching 1,718,000 hr. yearly by 1970.

An encouraging sign is that in the first half of 1956, student pilot licenses issued were up 27% over the same period in 1955, and perhaps significantly, operators report that increasing numbers of people who learned to fly in 1945 and 1946 are taking up flying again.

CAA is working on developing new flight instruction curricula with the emphasis on students receiving adequate instruction in basic flight instruments.

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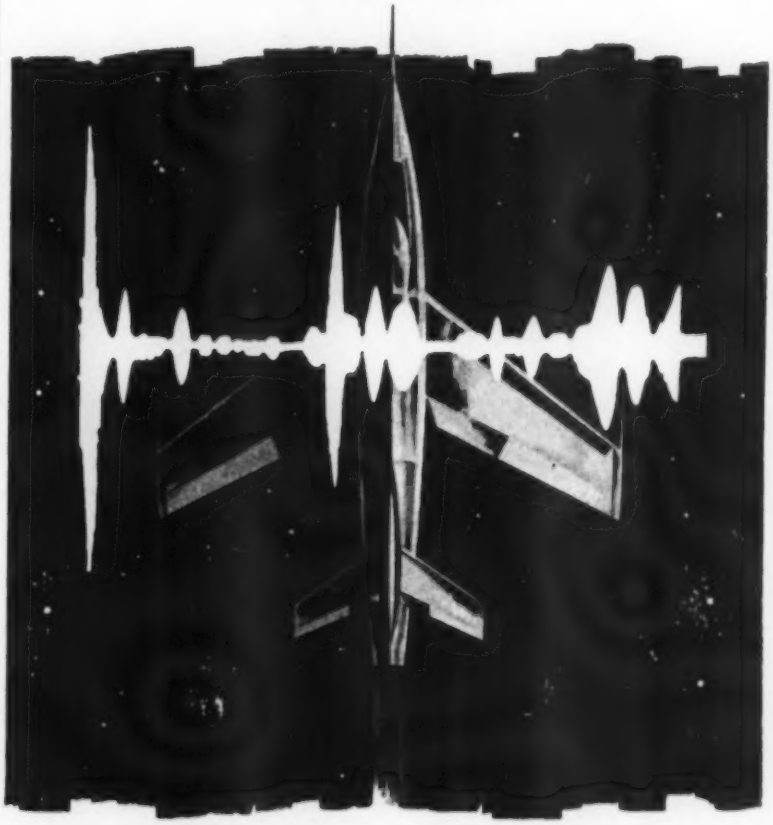

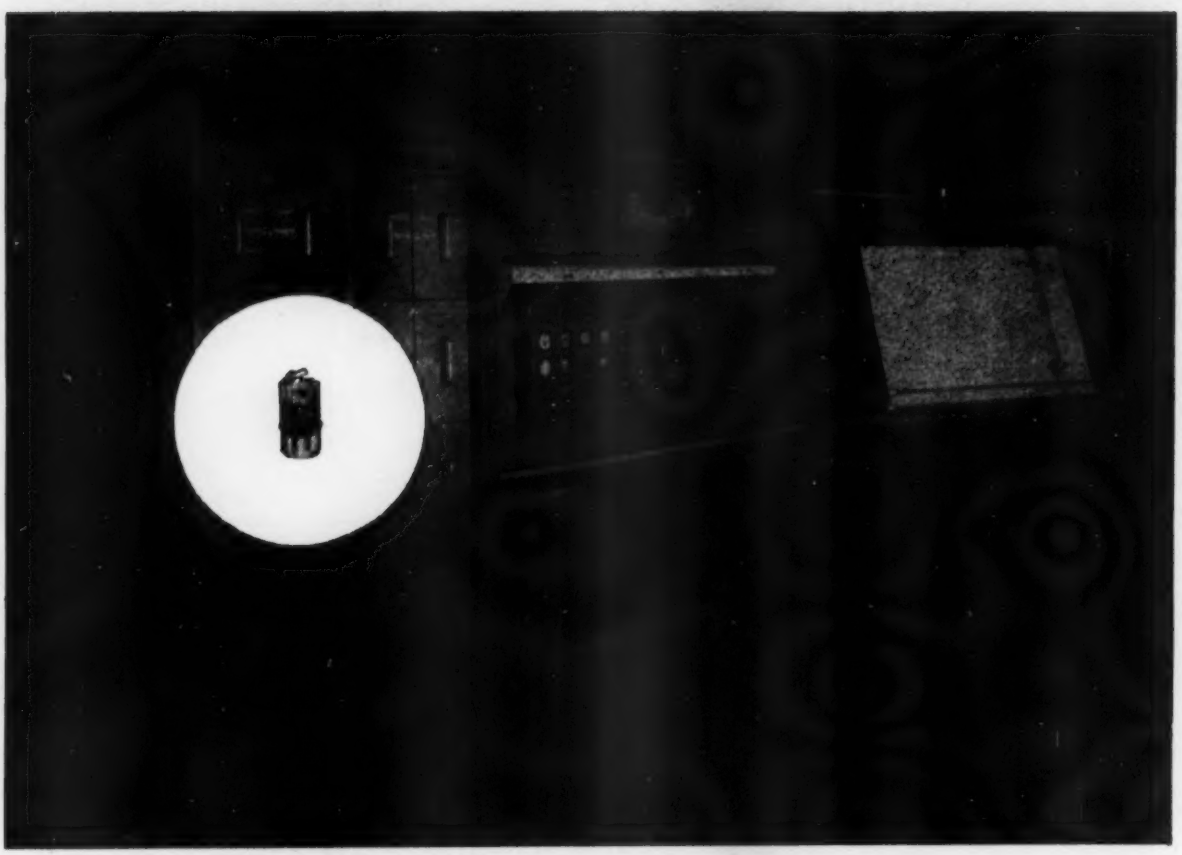

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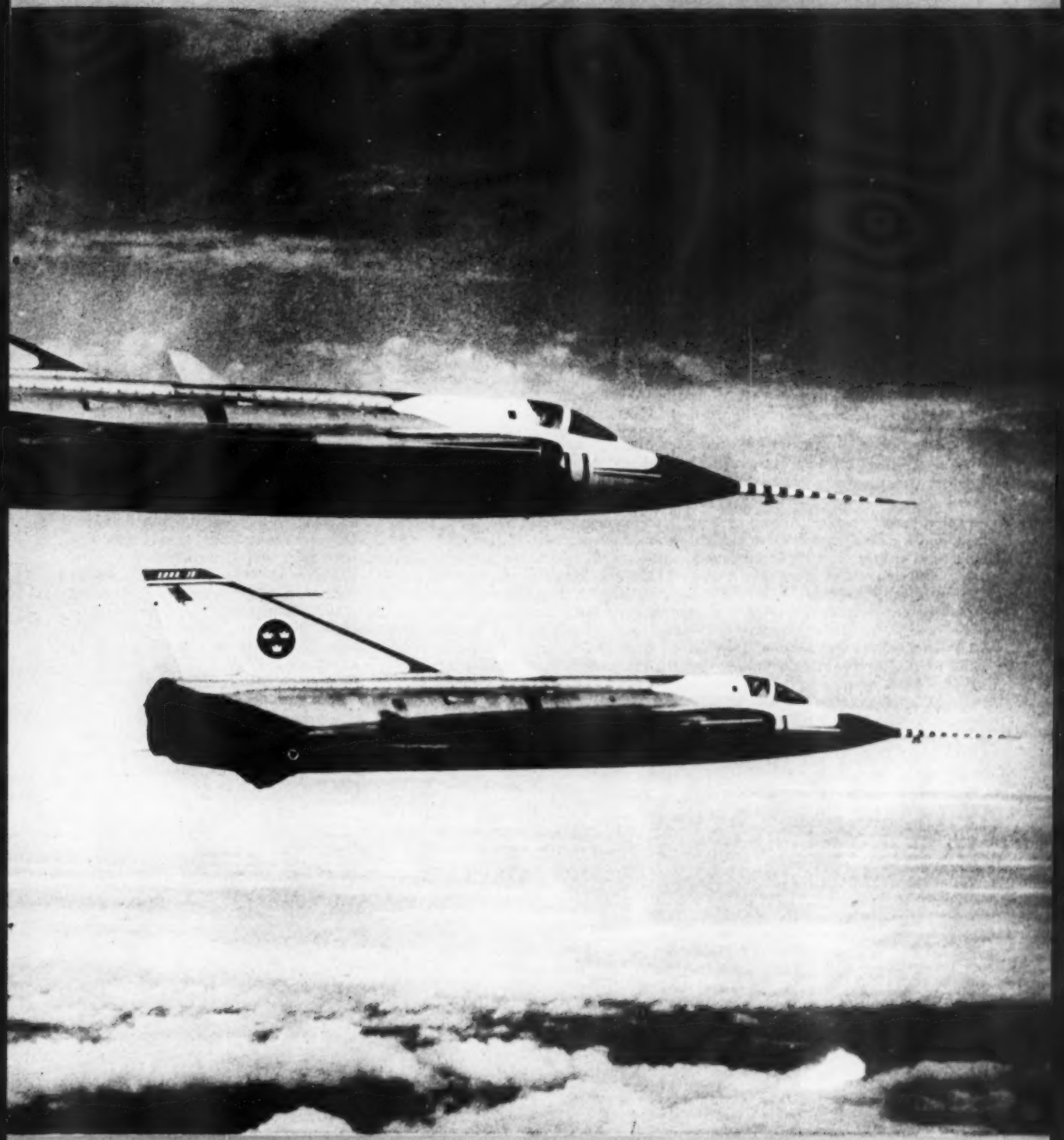
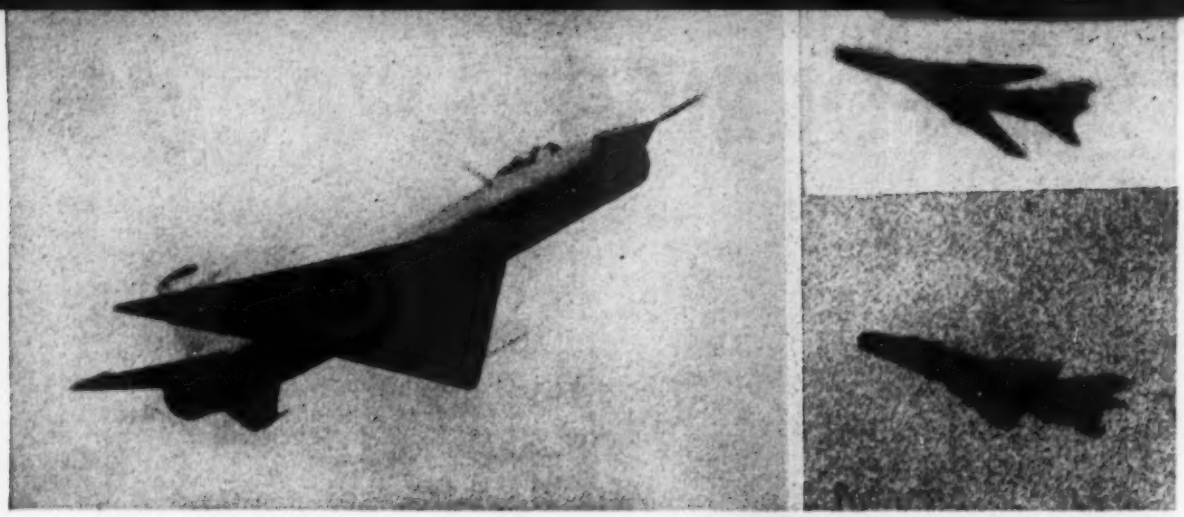


Saab J35 Draken double-delta wing all-weather fighter now in production for Swedish air force typifies originality which has marked many recent European designs. Double-delta offers low drag, good lift distribution.



SUKHOI DELTA-WING FIGHTER PROTOTYPES

Soviets Test IRBM, Mach 2 Fighters,

By Robert Hotz

Airpower of the Soviet Union demonstrated continued technical progress during 1956 in both military and civil categories. Among the outstanding technical achievements which the Russians demonstrated to the Western world were:

• **Intermediate range** ballistic missile capability. The Soviets accelerated their test firings of a 1,000-mile range missile to an average of five per month during the last six months of 1956, indicating the program has passed from development to production testing.

• **Mach 2 fighter development.** Experimental models of a Mach 2 fighter--the Super-Farmer (MiG-21)--were flown before Western observers at the Tushino air show last June.

In addition three experimental delta wing prototypes with capabilities close to Mach 2 were also demonstrated publicly.

• **Mach 1 fighters in service.** During 1956 the 900-mph. Farmer (MiG-19) went into widespread service with the Red air force replacing the 750-mph. MiG-17s (Fresco) as the standard Soviet day fighter.

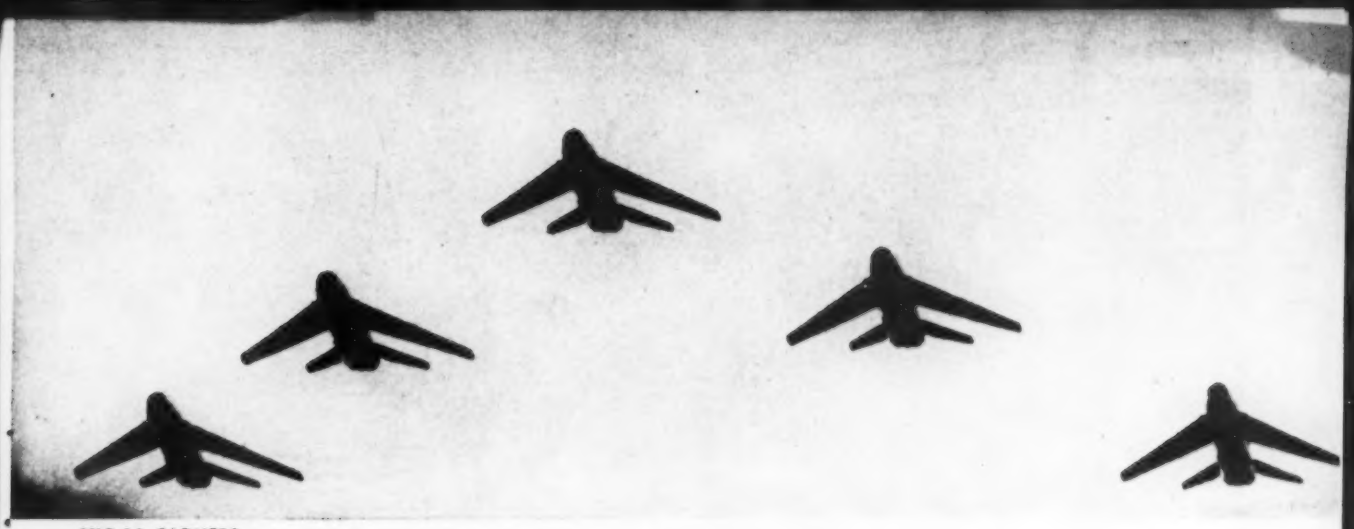
• **Supersonic all-weather** fighter development. The Super-Flashlight, a sweptwing supersonic all-weather fighter prototype, was publicly demonstrated at Tushino.

• **Supersonic bomber development.** Prototype of a light bomber capable of speeds just over Mach 1 was flown in rehearsals for the Tushino show and later exhibited to USAF visitors on the ground.

• **Gas turbine transport development.** In addition to being the only nation in the world to operate turbojet transports in regular airline service during 1956, the twin-jet Tu-104, the Soviets demonstrated a new turboprop powered assault transport. They also revealed plans for development of three more types of larger gas turbine powered transports.

• **Aerial refueling development.** Red air force officials confirmed that they have been experimenting with both probe and drogue and flying boom types of aerial refueling systems to ex-

YAKOVLEV SUPER-FLASHLIGHT



MIG-19 FARMERS

Operate Jet Transport

● USSR

tend range of their jet bombers. Soviet air force leaders indicated they preferred the probe and drogue systems. A pair of Badger bombers equipped for aerial refueling were displayed to the USAF delegation at Kubinka Airfield near Moscow, indicating that the Soviets favored the "buddy" system of field conversion of bombers for tanker missions over the USAF concept of a separate fleet of tankers.

Russian Invitation

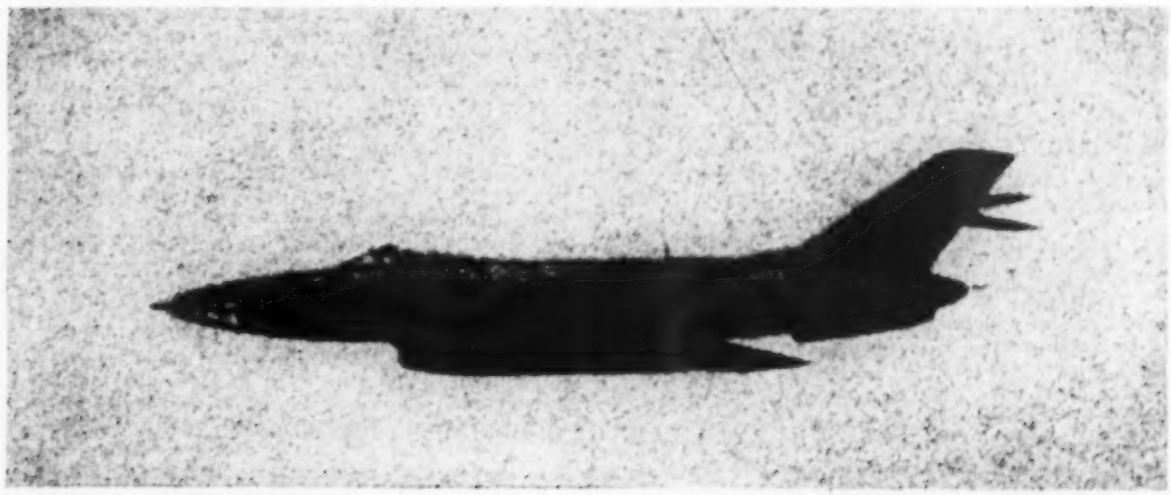
During 1956, top level USAF officers got their first real look at Soviet airpower when they were invited by Marshal Pavel Zhigarev, chief of the Red air force, to attend the National Aviation Day flying display at Tushino just outside Moscow, and to inspect military aircraft, engine and airframe plants and aeronautical training schools in Russia. The U.S. delegation headed by Gen. Nathan F. Twining, chief of staff, included Lt. Gen. Donald Putt, deputy chief of staff for research and development; Lt. Gen. C. S. Irvine, deputy chief of staff for materiel; Lt. Gen. Thomas Power, commander of the Air Research and Development Command; Maj. Gen. Albert Boyd, deputy commander of ARDC for weapons system management and USAF's most experienced experimental test pilot, and Brig. Gen. William Blanchard, operations chief of Strategic Air Command.

During its ten days in Russia, the USAF delegation witnessed at Tushino flying display a demonstration of seven new experimental prototypes in addition to the more familiar types already in service with combat units; inspected all the new prototypes and current Red air force first line aircraft types on the ground at Kubinka Airfield; visited the Red air force academy at Monino; inspected the Zhukovsky Air Engineering Academy in Moscow, and toured two aircraft factories in Moscow where Il-14 transports and centrifugal type turbojets of basic British design were being manufactured.

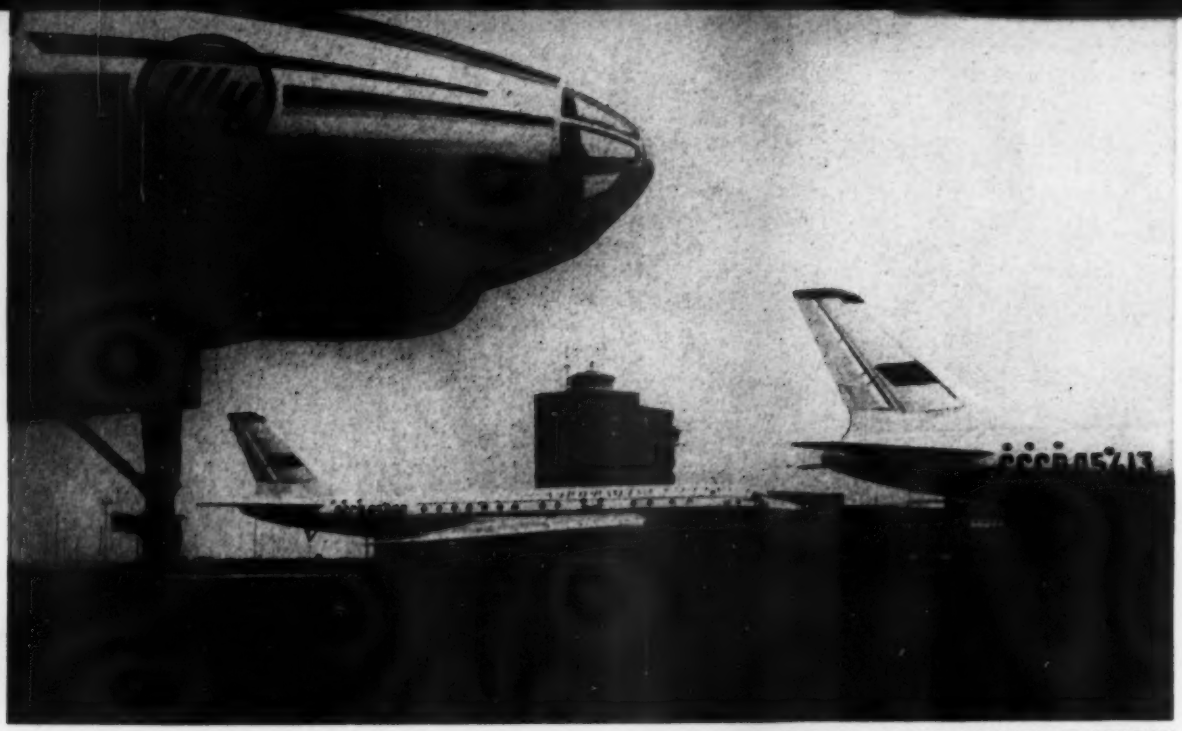
Twining Conclusions

On his return from the Soviet Union, Gen. Twining presented a detailed report to the Senate Armed Services Committee in which he cited five conclusions:

- **"On the basis of what we saw or were told,** the Soviet air force is engaged in developing a surprisingly wide variety of aircraft.
- **"It was the judgment** of my group



SUPER-FLASHLIGHT WITH BOMBARDIER NOSE



TUPOLEV 104 JET AIRLINERS AT LONDON

that the design configuration of most of these aircraft reflected a high level of scientific and engineering talent. They were proof that the Soviet designers are now pioneering on their own in the field of modern aircraft development.

• **"It was further our judgment,** at least on the basis of aircraft shown us, that despite the undeniable strides made by Soviet designers, they have not outdistanced us. Nothing we saw could be honestly described as being superior to the best U.S. aircraft in comparable categories. In saying this I must note that in certain areas—notably the development of turboprop bombers—they have made a large effort in that direction, that, for reasons of our own we did not choose to take.

• **"Three experimental** delta wing fighters shown at Tushino appeared to us to need still further test and development before they can get into series production. It was also our general conclusion that in the latest operational types as well, Soviet designers are having trouble achieving stability at high speeds. This was evidenced among other things by their extensive use of wing fences and foils to adjust the stream of air over wing and control surfaces.

• **"Nevertheless,** despite the absence of some engineering and design refinements familiar to us, the widening variety of aircraft already in the Soviet experimental and operational inventories is clear evidence of a broad understanding of the state of the aeronautical art and of Soviet determination to advance therein on a very wide front."

The Soviet Air Force is now completely equipped with modern jet types except in the transport category. The MiG-15, first swept-wing fighter to see widespread service with the Soviet Air Force, is now phased out of first line combat units where it was replaced by the MiG-17 (NATO code name—Fresco). The MiG-15 has been used to bolster fighter units of satellite air forces, notably Poland, Czechoslovakia and China.

The MiG-17 represented a major performance improvement over the MiG-15, with the addition of a more powerful version of the Russian-built, Rolls-Royce-designed centrifugal flow turbojet and an afterburner. Structural beef-up necessary to eliminate some of the MiG-15 problems at transonic speeds also was added to the MiG-17 design. MiG-17s are still widely used in the Soviet Air Force but are rapidly being replaced by the MiG-19 (NATO code name—Farmer).

The Farmer represents a basic departure from the earlier MiG design line. It has incorporated a number of new aerodynamic features mandatory for a straight and level supersonic performance. These include a thinner wing, low set horizontal tail and more streamlined cockpit. The Farmer also abandoned the barrel-shaped fuselage of the earlier MiG designs in favor of a broader and flatter fuselage designed to accommodate two axial flow turbojets of extremely small frontal area. The Farmer has about the same performance characteristic as the North American F-100 Super Sabre.

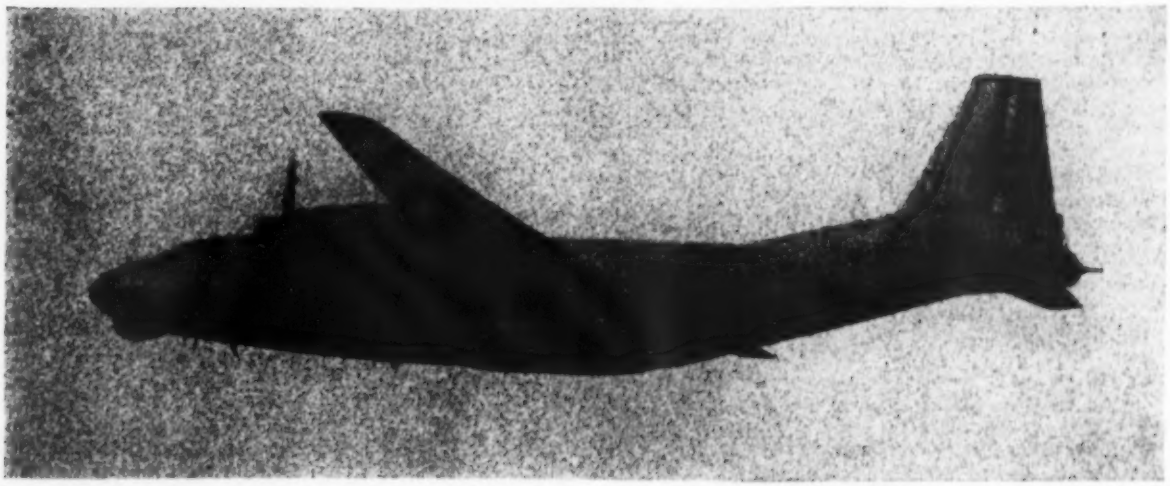
There is further evidence that the Farmer will be succeeded by another basic design improvement of the Mikoyan design group called the MiG-21 Super Farmer. First displayed at the 1956 Tushino air show, the MiG-21 prototypes were larger than the Farmer—indicating a more powerful engine installation—and are officially credited by the Russians with a 1,200 mph. level flight speed at altitude. This would make the MiG-21 roughly comparable to the Lockheed F-104, North American F-107 and the Grumman F11F-1F.

Design Cycle: U. S. Vs. USSR

The time phasing of Russian fighter development since 1947, when the first swept-wing prototypes flew in both the USSR and the U.S., indicates there is little difference in both the speed of the development cycle and the performance achievements of either competitor.

In the all-weather fighter category the Russians have developed a major model improvement over the twin engine Yak-25 (Flashlight) design that is now their standard service model. The new model called the Super-Flashlight also was demonstrated publicly for the first time at Tushino last June. It features a cranked wing planform using one degree of sweep from the fuselage to the engine nacelle and another outboard from the nacelle to the wing tip. It has larger and more powerful axial flow turbojets than the Flashlight and a pointed radome, indicating extremely advanced electronic technique. There is little doubt that the Super Flashlight is capable of Mach 1 in level

BISON FOUR-JET BOMBERS



ANTONOV TURBOPROP ASSAULT TRANSPORT

flight or that it carries its rocket armament internally. However, it appears to be slightly below the Convair F-102A in all around all-weather performance.

Il-28's Successor

The Ilyushin 28 is still the standard Red Air Force light bomber in addition to seeing wide service with the Soviet Navy and satellite countries, particularly China. It is subsonic and offers little strength against a modern air defense system. However, a replacement for the Il 28 is now flying in prototype form, although it does not appear to be very far advanced along the development cycle toward production.

This new light bomber (NATO code name Blowlamp) is a twin-engine design using axial flow turbojets housed in pods attached directly to the under surface of the swept-wing. Use of approximately fifty degrees of wing sweep and a relatively thin wing section indicate the Russians claim for Mach 1 level flight speed for Blowlamp may not be exaggerated. Tail design, which features the horizontal tail about midway up on the stabilizer, indicates that Blowlamp's maximum performance cannot be much over Mach 1.

In the larger bomber categories, the Soviets have exhibited no new developments since they unveiled the trio of Bear, Bison and Badger in 1954. First hand looks at these aircraft in Russia revised some earlier impressions gained from flight photographs taken at relatively long range.

The Bear, powered by four 12,000 eshp. turboprops driving contrarotating propellers, is much larger than earlier reports indicated, grossing well above 300,000 lb., and approaching the size of the B-36. There is little doubt that the Russian claim of intercontinental range for the turboprop Bear without refueling is valid.

Bison, powered by four 19,500 lb. turbojets, is considerably smaller than the B-52, while the Badger—powered by two of the same power engines—is smaller than the B-47.

Most significant revelation of the Soviets during the Tushino display was their development of an aerial refueling capability for both the Bison and Badger utilizing the "buddy" system of converting bombers for tanker use on specified missions rather than developing a specialized tanker aircraft as USAF has done with the KC-97 and the KC-135. Russian air officers said they had achieved a 25% range increase for their two jet bomber types with a single aerial refueling and a 50% range increase with two refuelings.

Since the bomber development cycle is considerably longer than that of fighters, it is probably too early to ex-

pect new Russian medium and heavy bomber developments to appear publicly even in prototype form. But from all the other evidence on the scope of the Russian air development program, there is little doubt that such new developments are under way including a nuclear-powered aircraft.

A major drive in transport aircraft development is under way to eliminate a major Soviet weakness in this category. Standard Red air force transport and carrier for paratroops is the Ilyushin 14 powered by two piston engines and comparable to an early model Convair-Liner. The Russian aircraft industry is developing a whole family of gas turbine powered transports to modernize both civil and military air transport in the Soviet Union. Among the types already identified by Russians as in production or under development are:

• **Tupelov Tu-104,** twin-jet transport with a capacity of about 45 passengers, now in Aeroflot service between Prague, Moscow, and Khabarovsk in Siberia.

• **Tupelov Tu-114,** four-jet transport aimed at 90 passenger capacity, now in prototype flight test stage.

• **Ilyushin 70-passenger transport** powered by four turboprops now in the prototype test stage.

• **Undesignated turboprop** transport design aimed at carrying 150 passengers in a double-bubble type fuselage.

• **Antonov twin turboprop** assault transport featuring truck bed level loading. This aircraft flew in prototype stage at Tushino but later evidence indicates its development may have been dropped in favor of a four-engine design of larger cargo capacity.

Soviet Strong Points

In general, Soviet aviation exhibits the following strong points:

• **Advanced powerplant** development. Russian airframe designers have an abundance of power with which to work. By sponsoring powerplant research and development independent of airframe projects, the Russians have been able to achieve major state of the art improvements in their entire family of gas turbine and rocket powerplants.

The belated adoption of this powerplant development philosophy by the U.S. military and industry is the best tribute to its effectiveness. The abundance of power available to Soviet designers accounts in some measure for the lack of aerodynamic sophistication in many designs. Where U.S. designers need every aerodynamic refinement to achieve performance because of marginal power outputs, the Russian designer can skip these details and literally blast his airframe to the required performance with the excess power available.

• **High priority on research** and development. The extremely wide scope of the Soviet air development program, ranging from helicopters and transports to supersonic fighters and intercontinental bombers, indicates little budgetary restriction on this effort and a high priority determination to push ahead at a maximum rate of progress on the whole broad front rather than concentrate on a few predetermined areas. In contrast, U.S. development is becoming increasingly narrow because of budgetary restrictions.

• **High priority** on aeronautical education. Soviet educational effort has given top priority to turning out the quantity and quality of engineers, scientists and technicians required to support the broad development program. Evidence of the priority placed on this effort was seen in Mach 3 and Mach 5 wind tunnels used in the Zhukovsky air engineering academy and the widespread propaganda aimed at luring the cream of Soviet youth into the aeronautical program.

• **Simplicity of production techniques.** Part of the Soviet secret in cutting the development cycle is simplified production methods. Wherever possible, techniques are aimed at reducing the time and energy required in the manufacturing process without the sacrifice of essential performance in the end product.

Weak Spots

Among the major weak spots evident are:

• **Avionic development.** Both ground and airborne avionic equipment displayed as standard service equipment is at least a generation behind similar service items in this country.

• **Personal equipment.** Russian air crews still operate in the leather jacket, high boots and helmet and goggle equipment characteristic of World War II. Although cockpits of modern fighters and bombers are pressurized, there is no evidence of advanced personal equipment such as G-suits or partial pressure suits.

• **Training.** Training of air and ground crews is a major problem for the Red air force involved in both an expansion program and a switch from piston to jet technology.

An overall summary of Soviet air strength in relation to that of the U.S. indicates that, while we still possess a measurable margin of superiority in the total resources of effective airpower, the Russians are making progress at a more rapid rate, primarily because of the higher priority assigned this sector of their total effort. Unless we increase both the scope and speed of our airpower development program, we face the real danger of being surpassed by the Soviets in the foreseeable future.

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● CANADA

Canada Seeks Aircraft Business Abroad

By William Gregory

Ottawa—Canada's aircraft industry, whose growth to third in employment, ninth in sales among Canadian industry, was begun virtually by government fiat 10 years ago, shows signs of becoming a bigger competitor in the world market in 1957.

Partly this is a search for stability, in the face of further tapering of military production which spurted during the Korean War.

Problem shapes up this way: Canada's airframe industry, which consists of three major companies, has spawned a supporting components supply network of 2,500 companies in addition to the 55 companies specializing in aviation. Stretch-outs have left many supporting companies with not quite enough business to make money.

Though Canada has no formal "Buy Canada" policy, there is a definite understanding that Canadian airframe manufacturers will buy components in Canada where available. In some cases, existing Canadian companies have gone into the aircraft component field; in others American and British companies have opened subsidiaries.

How far this trend has carried is shown by two examples:

• **Orenda Engines Ltd.**, bought 95% of components for its Orenda engine outside Canada when it started to build the engine for the CF-100. Today a fraction more than 95% are bought within Canada. Only a Bendix-made starter-generator is foreign made.

• **Canadair Ltd.** formerly procured 35% of its component parts outside Canada. It has whittled that portion down to 10%.

Basically the industry looks to the government as its best guarantor of stability. Industry leaders, pointing out that the industry cannot be turned off and on like a faucet, are calling for a clearly defined long-range national policy to maintain an industry capable of meeting Canada's defense and commercial requirements.

Export Hopes

Such a policy is unlikely to be defined in Canada this year, with elections called for June and the dominant Liberal party, running for re-election, holding a bent toward social welfare. In the meantime there is hope for exports, based on these developments:

• **Orenda** believes there is a good chance one of the four American engine-makers which have shown interest in its new PS13 Iroquois engine will sign a license agreement to produce the engine in the U.S. The engine, which is rated at 20,000 lb. thrust or 30,000 lb. with afterburner, is a planned effort by Canada to skip two generations in engine development, that is, to move one step beyond the J75-J79.

• **De Havilland Aircraft** of Canada, which has sold its Otters and Beavers in 55 countries including more than 600 Beavers to the U. S. Army, has orders from the U. S. Army for five DHC-4 Caribous, a twin-engine light cargo-transport now in mockup stage.

• **Canadair Ltd.** has an order for 225 Orenda-powered Sabre 6 fighters for West Germany. One of the major reasons for the sale was provision for crew training for the airplanes by the Royal Canadian Air Force. Even so the Germans, though unable to buy American Century series fighters, could have bought British or French types.

Canadair also has a jet trainer design which might offer export prospects.

Canadian observers take a hopefully pessimistic attitude on air export prospects.

The industry, with labor costs lower than in U.S. but higher than Britain and volume usually lower than the U.S. has been able to stay competitive in price. However, Canada's manufactured exports usually have lagged behind raw material exports, and last year Canada found itself with a $1 billion trade deficit with the U.S.

Dependence on Government

The real paradox of the Canadian industry in breaking its dependence on government orders is that it needs some initial government support, at least, to undertake a project with commercial or export potential. A case in point is the history of Canadair's CL-21 project.

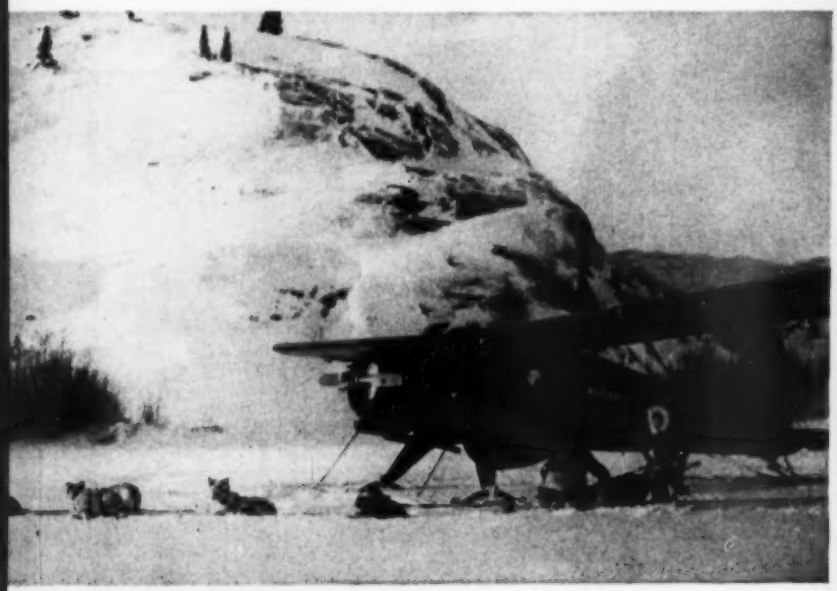
A replacement for the DC-3, the 32-passenger CL-21 was the subject of an extensive market survey in 1952. To compete with the Convair-Liner, then priced at $650,000, Canadair decided the CL-21, considering speed, payload, range, etc., would have to sell for $450,000 per unit. Here is how the situation looked after the 6-month survey was completed:

• **Potential worldwide market,** based on survey of 200 airlines, was 300 airplanes.

• **Break-even point,** to get back $135 million for the $135 million investment required, was 237 airplanes.

• Sales could easily fall short of the 63 profit units, taking into consideration product was a dollar one, and that Canadian dollar was harder than U. S. dollar; that potential customers were operating on lean budgets, and that a number of smaller operators did not have sufficient equity in their companies to swing necessary bank loans.

It was too "dicy" a gamble for Can-



DE HAVILLAND BEAVER

CANADAIR CF-100 WITH VELVET GLOVE

adair's board of directors. What would have pushed the project over the top would have been initial military orders for 50-75 units.

The moral is the same as that of Avro's C-102 four-engine jet transport project, the mockup for which was ordered dismantled just after the first of the year. With only 207 medium to heavy transports flying in Canada, and a relatively small home defense market, private financing of commercial or military ventures is impossible except for light, uncomplicated airplanes. Thus Canadian industry has had to cut its designs to fit Canadian military requirements, and can only hope the product might fit a wider market.

Near Outlook

Short-range outlook for the airframe industry is generally good:

• **Avro**—Though CF-100 production is being stretched out, the prime reason is to phase out the program smoothly with beginning of the CF-105 delta wing supersonic interceptor program. The Iroquois powered CF-105 is scheduled to fly "sometime this year."

• **Canadair**—Besides the German order, and its CL-28 maritime reconnaissance airplane, Canadair probably will be prime contractor for the Sparrow air-to-air missile with which the Mark 6 version of the CF-100 will be equipped. Orenda is developing an afterburning version of the engine in the CF-100, designated the 11-R.

• **De Havilland**—Besides its Beaver, Otter and Caribou programs, de Havilland is scheduled to go on building the CS2F under license from Grumman for the Royal Canadian Navy into 1959.

Stretch outs, like the CF-100 program, and military buying as in the case of the CL-28 where orders were placed in small, separate batches, has caused airframe manufacturers to limit component buying to immediate needs.

Component manufacturers, who need to operate on the average at 50% of capacity to break even, have fallen to about 34% capacity. The industry plans to bring the problem to the attention of the government.

Long Term Recommendations

Several recommendations for a long-range program for stability have been made.

Avro proposes:

• **Expansion of research** and testing facilities.

• **Production program** to ensure continuation of operations at a level to permit industry to retain essential engineering and production staffs, and facilities in readiness for rapid expansion.

Canadair favors:

• **Planned replacement** policy for the RCAF using the latest type of equipment available, which might result in Canada becoming a regular supplier of aircraft on an export basis.

• **Encouragement of Canadian** design and development of aircraft and equipment, not only to provide aircraft to meet Canada's own particular needs and which are not available elsewhere, but also to preserve a high degree of technical skill in the aircraft industry so that license arrangements can be carried out successfully.

As 1957 begins, the industry sees two logical areas for RCAF procurement:

• **Transport**, either to replace the RCAF's aging North Star, a Rolls-Royce Merlin engine version of the C-54—DC-6 design, or to supplement the RCAF's North Star and C-119.

• **Trainer** (or trainers), probably a jet

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trainer to replace the North American Harvards (T-6s) in RCAF.

When the UN emergency Suez airlift was ordered, RCAF had four C-119s repainted with UN insignia and airborne on the way to Naples in 48 hr. Eventually 12 C-119s, an augmented squadron, were based at Naples, airlifting troops to Port Said, via Crete, and returning nonstop. North Stars supported the Naples operation with a transatlantic service.

Mechanically, the airplanes held up satisfactorily—the C-119s flew 1,000 hr. in the first four weeks of the airlift with only one abort from engine trouble. Logistically the operation was a strain, obtaining parts for North Stars at bases unused to receiving them, for example. Besides, RCAF Transport Command had its routine commitments to keep, including three weekly transatlantic flights to support the RCAF air division in Europe, and transpacific airlift in support of the Canadian Indo-China Truce Commission. It was a tight fit.

Military Transports

RCAF has a requirement in the mill that would fit the CL-44, a transport version of the CL-28 which Canadair hopes to build. A letter of intent for the purchase of the airplane has been prepared by the Department of Defense Production, but this does not mean a contract is sure to follow.

Complicating the situation is the interest of the Canadian Army in de-Haviland's DHC-4 Caribou STOL twin engine transport. De Havilland will build two prototype airplanes to a Canadian Army requirement, but any implications on who will operate the airplanes are being carefully avoided. Canadian Army does operate some Cessna L-19s now. There also is some government interest in the U.S. style combined military transport operation.

Defense estimates for Fiscal Year 1957-58 allot $215 million for aircraft procurement, $18 million more than 1956-57. Canada is reequipping four of its 12 NATO squadrons in Europe with CF-100s, and is adding three CF-100 squadrons to its nine existing home based squadrons of this type. Out of these funds also must come CF-105 development and the missile program.

Canadian defense spending will decline somewhat this year because of completion this summer of the Mid-Canada line, which was a boon financially to Canadian charter and airline operators who took part in the construction airlift. Operators will continue to benefit from supply airlift, however.

Trainer Indecision

Though the transport order may figure in this year's spending, the trainer

is farther in the future. One reason is that the RCAF disagrees within itself as to the best way to train beginning aviators. At the same time, normal attrition will eventually demand replacement of the Harvard.

After using the Harvard as an *ab initio* trainer, the RCAF went back last year to the lighter 140 hp. Gypsy engine Chipmunk to train beginners. The change meant an additional order for 60 Chipmunks, which de Havilland delivered last year.

Students get 25 hr. in Chipmunks and 150 hr. plus in Harvards. RCAF finds the new system more economical in instructor time—students solo a Chipmunk in 10 hr., compared with 25 hr. in Harvards—and also in weeding out students with no aptitude in a trainer less costly to operate.

Canadair, Avro and de Havilland all have ideas on a new trainer, but Canadair's design for a light jet trainer is farthest along.

Whether the RCAF will shift to jets for beginners eventually is now being argued within the service—the older officers tending to favor the light piston engine airplane and the younger men the jet.

In any event, the trainer is virtually certain to be built in Canada, but its choice may well be indebted to U. S. and British experience.

Foreign Subsidiaries

U. S. companies whose subsidiaries operate in Canada, are facing the possibility that Canada will insist on some distribution of ownership to Canadians.

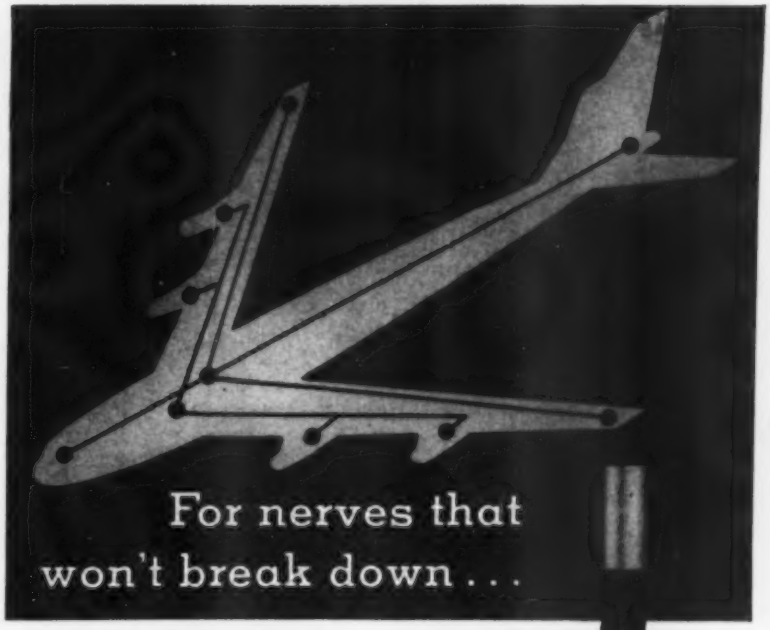
Diplomatic officials concerned with aviation are watching this situation closely, for last fall Avro, an English owned firm, made 10% of its shares available to Canadians. This raised a subtle challenge to Canadair, the only large American owned airframe company.

However, de Havilland is attempting to buy back its subsidiary's shares.

The so-called Gordon report—a preliminary report of a government appointed Royal Commission designated to set down Canada's economic prospects 25 years in advance—suggested a policy of encouragement through tax benefits to companies which do make shares of their subsidiaries available for purchase by Canadians.

Opinion in Canada as quoted by the Financial Post, ranges from one extreme of "We've got to do something to stop pillage of our resources by foreign investors" to "How can you measure your disincentives so that you will restrain foreign ownership without choking off foreign capital?"

No early adoption of this recommendation is likely, but the specter will be a persistent one.



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● BRITAIN

British Set Out to Pare Industry Fat

By William J. Coughlin

London—Britain's aircraft industry is about to receive a blow which could knock some of the complacency out of it.

A big cutback is underway. Defense Minister Duncan Sandys of the new Macmillan government has made it plain that lean days are ahead for an industry which for too many postwar years has seen inefficiency rewarded by soaring profits.

Sensibly applied, the new program could produce an efficient industry capable of producing fine aircraft and guided weapons. Indiscriminately applied, it could result merely in a smaller industry with the same bug-laden prototypes and lagging production lines.

British officialdom is awakening at long last to the troubles which critics both inside and outside the aircraft industry have been pointing out for years.

Leadership Task

But the leadership to set the industry sternly on the proper course will have to come from the top and be ruthless.

The report to the House of Commons by the Select Committee on Estimates issued early this year contained some of the strongest language on the subject ever heard from an official body (AW Jan. 28, p. 26). It could provide a blueprint for pulling the industry out of the doldrums. Review of the defense position offers the opportunity for such an overhaul.

Required are elimination of some firms from the industry, unemployment, revision of government procedures, cancellations and—probably hardest of all in an economy drive—increased spending in some fields.

Billions Spent

Over $5 billion has been spent in Britain in the last ten years on military aircraft. Much was wasted. An unsteady program of research and development handicapped by inadequate research facilities led to too many production orders for too small quantities of aircraft.

Effect of inadequate basic research was summed up by a naval witness testifying before the Select Committee:

"The result of that is that the research into aerodynamics and high-speed flight and so on that has been going on in this country is not far enough ahead of staff requirements. . . . When the aircraft designer has to design an aircraft to meet staff requirements, he finds that what he is designing is, in fact, basically the type of aircraft that is being used in the research program then or about to be built for the research program. Thus, instead of getting, as he should, a lot of basic research information from aircraft that have been flying at Mach 2 or more which will help in the design of an operational aircraft, he has virtually to start from scratch."

Missile Lag

Much the same is true of guided missiles. At the end of World War II, Britain decided to pass up "interim" projects for a big jump ahead in the missile field. But without the information interim projects would have developed, the advanced program floundered. It now is estimated that the United Kingdom is two to three years—or more—behind the U.S. in this field.

Britain may turn to the U.S. for missiles and perhaps an advanced fighter such as the F-104 to fill the gaps while work continues on more advanced projects. Jumping over an intermediate stage, however, incurs the possibility of once again stumbling due to lack of basic information. Only a speed-up in Britain's research and development programs can provide the answer. If the economy axe falls here, Britain may buy another generation of trouble.

Since the failure of British policy at Suez, Britain has been considering its new role in world affairs and the military position which will follow. One con-

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clusion is that the U.K. will worry less about policing the world. It will pass that burden to the U.S. Thus money and technical manpower can be diverted from defense into industries which will strengthen Britain's competitive economic position. It will hasten a cutback already started in the military aircraft program.

Suez Lessons

Suez provided very little information about operational capabilities of recent aircraft. Valiants, Hunters and others were in action but the lack of opposition made it of little value. The damage to Egyptian airfields and military installations testifies to the accuracy of the British bombing. But in perfect weather against almost non-existent opposition, this doesn't offer any more opportunity for bragging than a similar performance at a desert bombing range.

The Suez operation did bring home dramatically the complete unpreparedness of Britain for an airborne operation. Lack of adequate transport aircraft handicapped an operation where time was a key factor. This basic flaw in a force presumably designed for defense of a sprawling commonwealth is difficult to explain.

Present position in military aircraft shows few bright spots and many dark ones. Former Supply Minister Reginald Maulding already was pruning the program before Prime Minister Macmillan took office:

• **Gloster's** plans for a thin-wing high-performance Javelin were scrubbed. There has been no indication yet of a severe cut in present production of the much-delayed Javelin. Perhaps 100 have been delivered out of an order estimated at 300. Thinking is that the Javelin will serve as an interim all-weather fighter until the all-weather version of the English Electric P. 1 or the Canadian CF-105 becomes available.

• **Supermarine Swift** finally reached limited service in 1956 but has been written off as a $92 million failure. Blown-flap N.113 coming into naval service is a generation behind its U.S. counterparts. Latest delay resulted from high speed pitch up. To cure this, the tail was redesigned; it now has anhedral instead of dihedral. Blown flaps cut 10-12 kt. off approach speed as well as improve landing attitude.

• **Vicker's production** of the Valiant bomber has been cut off. Last of these will roll from the assembly line this summer after completion of about 125 for the RAF. Production of the Avro Vulcan and Handley-Page Victor is scheduled to fall in behind this. Vickers will convert its Valiant line to Viscount 800s.

Avro has begun construction of the supersonic bomber prototype. First Vulcan has been delivered but the air-

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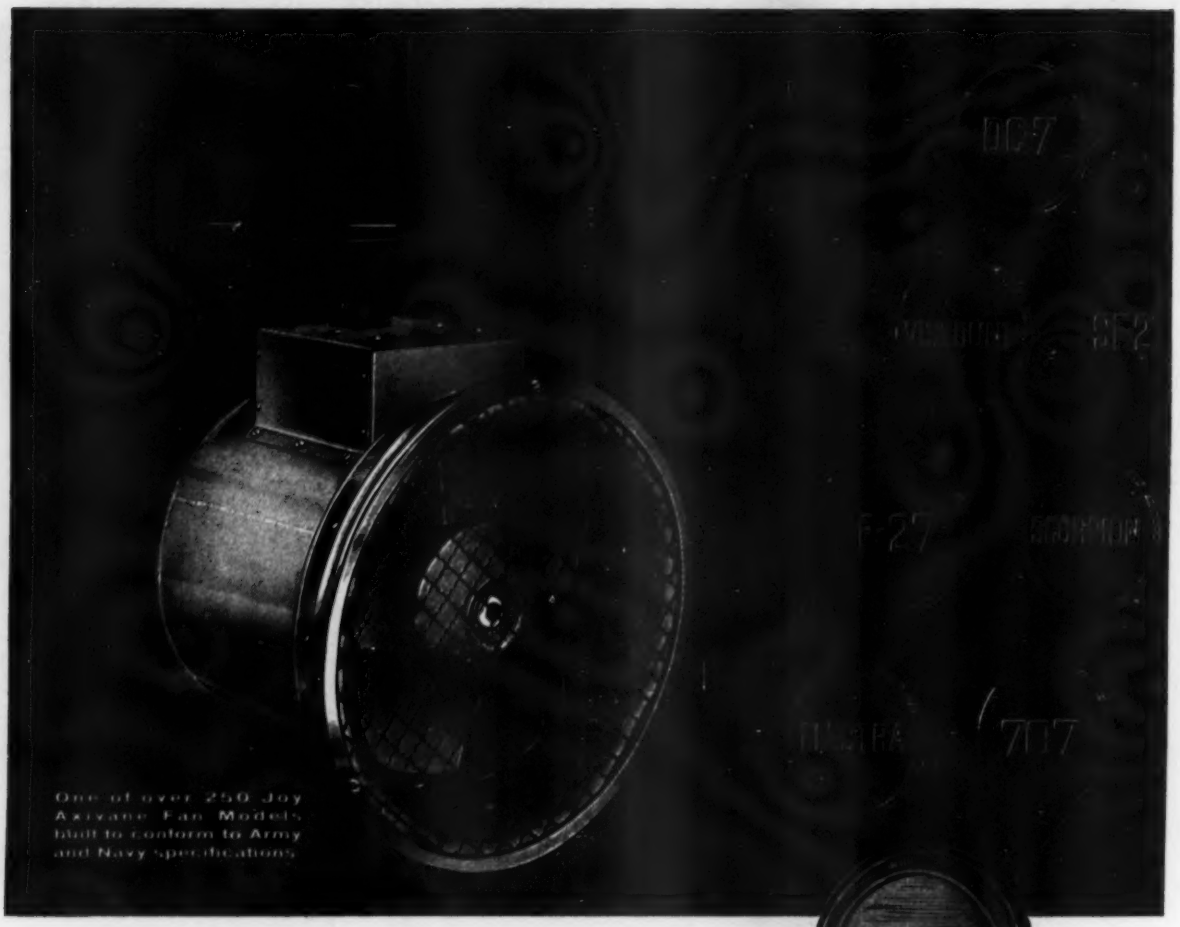

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craft is not yet in squadron service. Victor also may reach service this year.

• **De Havilland's naval DH 110** is just coming into production. First production version was due for February rollout. It has been beefed up, fitted with folding wings, and given such modifications as longer travel on undercarriage shock absorbers. About 100 are on order.

De Havilland is still turning out a trickle of Vampires for export as well at Sea Venoms and RAF Venoms. Latest Sea Venom uses the improved Ghost 105 engine. Rated thrust of 5,300 lb., an 8% increase in performance, was achieved by raising the speed of rotation as well as the temperature. Military airframe future at de Havilland is not bright, however.

• **Hawker was hit** by cancellation of orders for an additional 100 Hunters. It is virtually closing down its Langley plant. The company is continuing design of a supersonic fighter with its own money.

• **English Electric stands** in front in the fighter field with its supersonic P. 1 which already has exceeded 1,000 mph. and is said to be capable of 1,500 mph. Orders for a development batch of 20 have been followed by a large production order. The pre-production aircraft and the service version for the RAF will be the P. 1B powered by two Rolls-Royce Avon engines with afterburners. Design has been considerably altered over the P. 1A prototypes, of which three were built. Two Armstrong Siddeley Sapphires power the P. 1A. Two still are flying, and one has been ground-tested to destruction.

Hopes for this aircraft are high. Air Chief Marshal Sir Dermot Boyle, RAF chief of air staff, describes it as "a tremendous improvement on anything we have had before." RAF pilots at the Central Fighter Establishment report very favorably on its flying qualities and simplicity in handling.

• **Fairey Aviation** had hopes that its record-shattering delta-wing Fairey Delta 2 might be followed by a production order for a supersonic fighter but this has not materialized.

• **Saunders-Roe SR/53** rocket-jet interceptor now is at Boscombe Downs for testing. De Havilland Spectre rocket which will power it has not flown yet although it is due for testing in a Canberra shortly. The prototype will be powered by an Armstrong Siddeley Viper which will be replaced by a more powerful engine in production versions. De Havilland's lightweight Gyron Junior is a candidate as well as the Bristol Orpheus.

Research Aircraft

In the research field, there is a straight thin-wing supersonic aircraft of stainless steel which will carry aerodynamic probing beyond the capabilities of the Fairey Delta 2. There also is a program for a vertical take off research aircraft or similar design. Number of wind tunnels is increasing slowly. There now are more than 60 in Britain but only a handful are supersonic.

The guided missile program, while lagging considerably, also has a few bright spots.

De Havilland's infrared guided air-to-air missile is said to be coming along very well while there are reports of an English Electric surface-to-air weapon which shows promise.

Bristol is mating its Thor 16-in. ramjet to a missile similar to the Boeing Bomarc. Armstrong-Whitworth is at work on a ship-to-air weapon for the Royal Navy. This short-range missile is said to be powered by an Armstrong Siddeley motor with a Sperry guidance system.

Fairey Fireflash, announced with considerable fanfare in 1956 as Britain's first operational missile, has been relegated to a training role. It is, however, available for export installed on the Hunter.

Fairey is developing more advanced version for service use.

Russian Threat

Russia's threat to use ballistic missiles against Britain during the Suez crisis emphasized the importance of equipping the United Kingdom with similar weapons. English Electric and de Havilland are said to be involved in the intermediate range ballistic missile program.

Altogether more than 20 major firms are engaged in the guided weapons field along with several hundred component manufacturers.

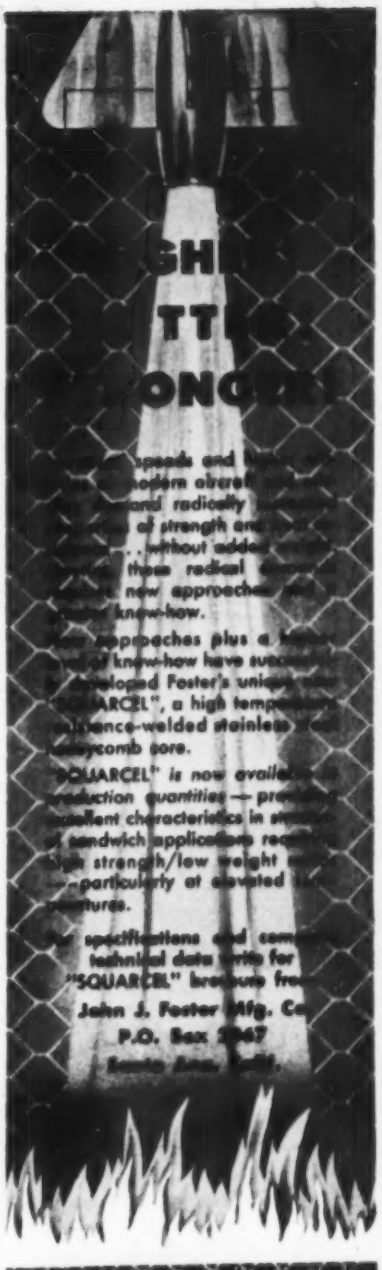
Export Success

Perhaps the most amazing thing about Britain's aircraft industry in view of its unsatisfactory record in the high-performance fields of military aircraft and guided missiles is its success in the civilian and export fields. The dollar market, already breached by the Vickers Viscount, was invaded during 1956 by the Bristol Britannia and the de Havilland Comet.

This cannot be considered too great a compliment since a major factor in both orders was the fact that the U.S. airlines concerned were attracted by early delivery dates which U.S. manufacturers could not meet.

But British manufacturers are counting heavily on these sales to convince other airlines that Britain has something to offer in competition with U.S. aircraft manufacturers.

Vickers, de Havilland and Bristol all have been vigorously combing the U.S. market. In general, they have gained the impression that U.S. airlines are



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busy at the moment digesting their big-jet purchases but will be making important decisions before the end of the year on turboprop and medium jets.

This year should top the record 1956 export figures with deliveries of both Britannias and Viscounts swelling the totals.

In the past ten years, exports have climbed from $56 million annually to $294 million.

Aircraft and parts counted for more than $200 million in last year's export trade. Engines brought in over $75 million.

Electronic exports jumped 20% over the previous year to top $7 million.

More than half the turbine airliners on order in the world are British, 496 against 485 at the latest count.

Viscount Lasts

Vickers considers the Viscount good for another five years. The 400-mph. Viscount 840 series is due for airline use in late 1959. First 840 will fly this September. Beyond that are payload and range increases. These could result in a Viscount with an extra five feet on its wings.

After that comes the first second-generation turboprop airliner, the Vanguard. Trans-Canada Airlines and British European Airways each have ordered 20.

More orders are expected shortly.

Vickers also is looking at the medium jet field.

Bristol has a strong interest in a medium jet as well as future developments of the Britannia.

Plans for a de Havilland 118 jet designed for 1962 use by BOAC caused a flurry until it was realized that this airplane would never be built. One industry source called it a "political aircraft." BOAC did not particularly need an airliner to those specifications and de Havilland did not want to build one.

A future development may be worked out in conferences between the two but the DH 118 as such has been dropped.

Political Airliner

Also somewhat political is the recent announcement of a supersonic airliner to be built by a consortium of seven major British manufacturers. There seems little doubt that this project will go ahead.

Whether it can best be accomplished by a combined effort can be questioned.

But the 1957 position of the industry is brighter than in the past. A promising supersonic fighter near production, a supersonic bomber under construction and a bright future in the civilian field offers strong promise when coupled with an awakening government realization of what must be done in this field.

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DASSAULT ETENDARD IV

French Sales High Abroad, Nil at Home

By Robert Farrell

Paris—Thin budget plus preoccupation with air policing problems in Algeria prevented any substantial build-up in French airpower last year. French Air Force ended the year by announcing substantial cutbacks in orders for latest jet equipment and it accepted a 1957 air budget which will mean another annual pause in its air power development.

Last year's air force combat squadron build-up was nil. Present combat strength is 40 instead of the 50 called for in FAF planning. Personnel strength remained steady at 146,000 and won't increase for at least another year. Under present air force thinking France by 1960 will have only 43 combat squadrons with 725 combat aircraft instead of the planned 60 squadrons and nearly 2,000 aircraft.

Despite a string of advanced prototypes, notably Ouest Aviation's Trident II interceptor which last month easily passed the official world speed record, no major orders for advanced jet equipment or missiles were announced during the year.

On the bright side, the French aircraft industry last year scored several successes in the export field. Sales or license deals signed in Far and Middle Eastern, European, Latin and North American markets involved the Dassault Mystere IVA interceptor, Nord twin-engine Noratlas cargo plane, Fouga Magister jet trainer, Max Holste Broussard, the Morane-Saulnier Paris executive jet, Sud-Est's Alouette helicopter and the two-place Djinn jet helicopter built by Ouest Aviation.

The industry entered 1956 with a foreign order book worth $45 million. It ended the year with foreign orders worth over $100 million. The French expect to crown their export drive this year with the first foreign order for Sud-Est's new twin-jet Caravelle transport.

The limiting effect of last year's air force budget on French airpower was partially offset by deliveries of the last of the Republic F-84Fs and RF-84Fs under the Mutual Defense Assistance Program (MDAP). Many committed to NATO instead were pressed into service by the Air Ministry during the Suez campaign.

DASSAULT MIRAGE

Outstripping Power

To many Frenchman, this campaign clearly demonstrated that French foreign policy had outstripped French military power to back it up. The necessity of relying on U. S. equipment for fighter-bombing chores, plus back-pedaling in the face of Soviet missile threats, embarrassed many a French military man.

These implications aren't reflected in present Air Ministry planning, the budget reveals.

Its 1957 budget of $817 million, a slight increase over 1956, represents only 28.6% of the total French military budget. By contrast, USAF funds amount to 46.3% of the American defense budget and airpower claims 35% of Great Britain's defense budget. Included in this year's $817 million air force budget is an item of $150 million for studies and the building of prototypes. Of this amount, $40 mil-

lion is earmarked for guided missile work.

Much of France's air defense funds are drained off by air policing problems in Algeria. The Air Ministry is probably spending more money on American heavy helicopters and surplus North American T-6s for use in Algeria than on its guided missile program. One hundred Vertol H-21s and 220 Sikorsky S-58s and 300 T-6s were ordered during the year.

Air Ministry is also spending large sums on several hundred small SIPA and Morane 733 trainer-fighters for Algerian duty. To man these light planes, air force draws heavily on its jet pilot pool.

Year-end announcement of important cutbacks (probably 50%) in orders for the Dassault Super Mystere interceptor and Ouest Aviation's twin-jet Vautour underscores a problem which the French industry must solve to stay in business. The problem is one of speeding up the delivery of aircraft in all phases, from development through production into operational use.

This calls for a great deal more cooperation between Air Ministry policymakers and the airframe industry. Very likely a final solution to the problem will lead the French to cooperation on a European level.

Super Mystere

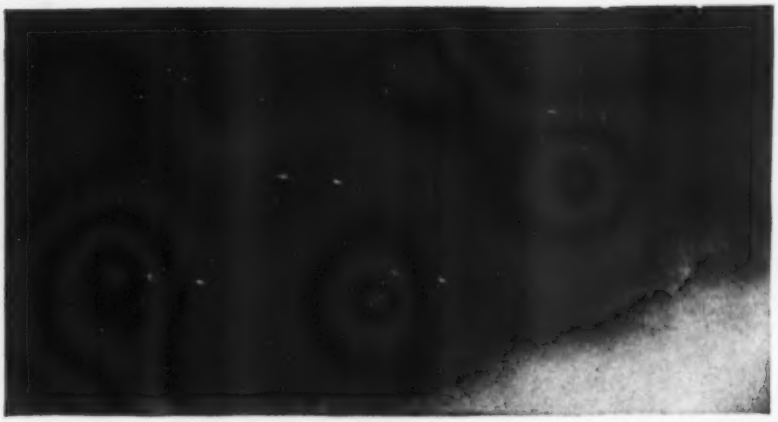
Dassaults Super Mystere, powered by a Snecma Atar IX delivering 9,240 lb. thrust with afterburner, is in a class close to USAF's F-100. But production models of the Super Mystere are just rolling off the line now. Under planned production the aircraft would be obsolescent well before final deliveries were made. Production rate on the Vautour, also just coming off the line, is even slower.

What is happening to the Super Mystere and the Vautour could happen the Ouest Aviation's Trident II, perhaps the most promising of the several advanced French prototypes. So far air force has ordered only 10 pre-production models. Ouest has three Tridents in the air. Two are being flight-tested for conventional interceptor use with pilot. The third is undergoing tests designed to convert the Trident into a pilotless retrievable missile.

Goal of the Trident testing program is to push the interceptor up to Mach 2. Mach 1.9 has already been reached. It is powered by two-chamber SEPR liquid propellant rockets located in the tail and two Dassault-built Viper wingtip turbojets of 1,650 lb. thrust each.

Trident Performance

Production model will have Turbomeca Gabizo engines rated at 2,400 lb. thrust, perhaps with afterburners. Trident has flown at 59,000 ft. a new



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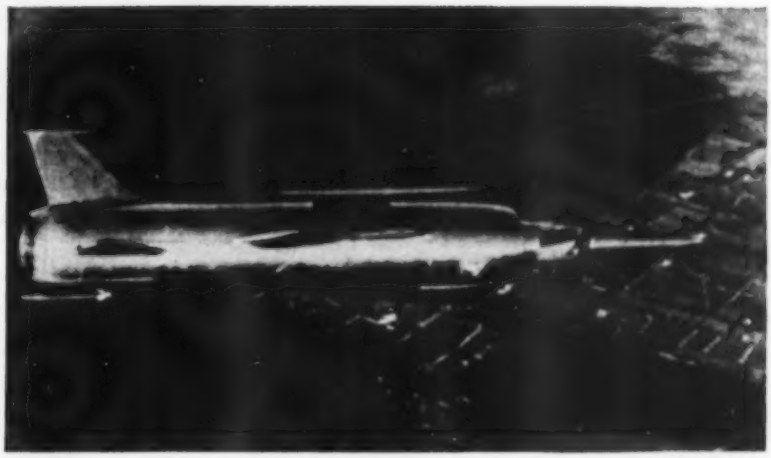

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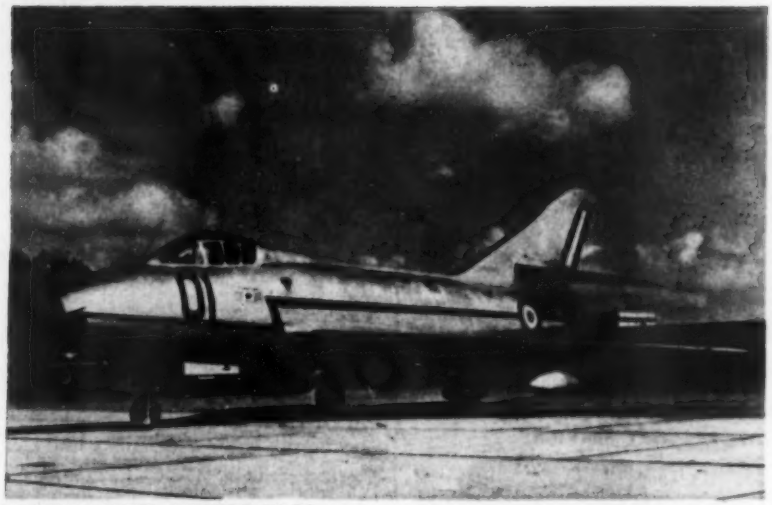

DASSAULT SUPER MYSTERE IV B2

French altitude record. Company says Trident II is capable of reaching an altitude of 50,000 ft. in 2 min. 30 sec. from brakes off.

Trident might be spared the fate of the Super Mystere if the Air Ministry would agree to share the aircraft with other European nations. Dutch, German and Belgian airframe interests would like to join with the French to fill any large scale order for the Trident—whether national or NATO.

More and more French observers are beginning to agree that cooperative arrangements of this kind between European interests—centering on the production of European aircraft tailored to European defense needs—is a much better formula than the U. S.'s MDAP program.

While busily engaged on production models, the industry turned out a promising stable of prototypes, mostly lightweight fighters and interceptors.

Leduc 022

Leading the list is the Leduc 022 ramjet-powered supersonic interceptor, first flown in December.

Unlike the Leduc 021 carried aloft by a mother ship, the 022 takes off under its own power using a Snecma Atar D.3 jet mounted inside the ramjet body. Designed for the Mach 2 speed, the 022 will undergo tests aimed at Mach numbers up to 4. The 022 has completed 12 flights since December, using only the Atar for power. Performance during take-off and landing, lifting more than 75% of its six-ton maximum weight, is reportedly equal to performances of present French interceptors. A second 022 is under construction.

Dassault's prototype tactical support fighters, Etendard II and Etendard IV, first flew last summer. Etendard II is powered by two Turbomeca Gabizo engines, the IV model by a single Snecma Atar. Dassault's third entry in the lightweight tactical support category, the Etendard VI, is still waiting for its Bristol Orpheus powerplant. The VI model, built with the aid of NATO funds, will compete in the NATO lightweight fighter contest.

Last November, Dassault's delta wing, lightweight interceptor, Mirage III, flew for the first time powered by a Snecma Atar G engine with afterburner. Level flight top speed is about Mach 1.5. The Mirage exists in two other versions—Mirage I and II, which are powered by a combination of jet and rocket engines.

No firm orders for either the Etendard or Mirage series have been placed by the French government. Navy has shown some interest in the Etendard IV, but only for five pre-production models.

Delta-Wing Durandal

Another delta wing interceptor prototype flown last year is Sud-Est's Durandal. Some reports claim Sud-Est may drop the Durandal and back the Trident as the best answer to European interceptor demands. Durandal is powered by Snecma Atar with afterburner plus SEPR JATO units.

The same powerplant, less the JATO units, is used in the Nord lightweight delta wing interceptor, the Gerfaut II, also flown last April. Nord seems to have shelved its earlier interceptor prototype, the Griffon, which made its first flight in September, 1955.

Another prototype revealed in controlled flight during the year was the Flying Atar, a wingless aircraft under development by the State-owned engine firm of Snecma. Consisting of an Atar turbojet of 6,200 lb. thrust, fuel tanks and control equipment, the whole unit weighs 5,600 lb., including fuel. Taking off either vertically or laterally,

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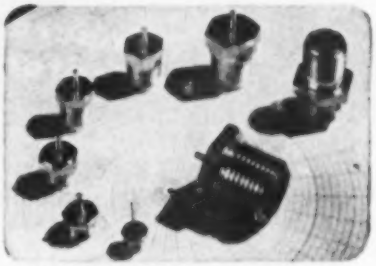

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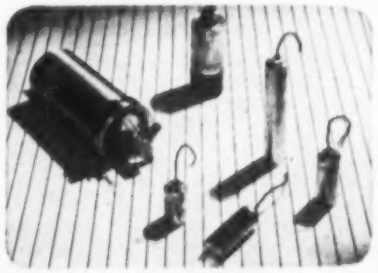

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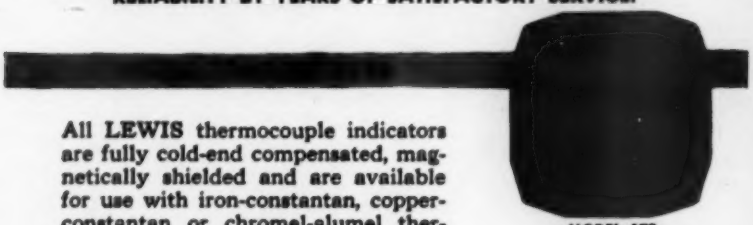
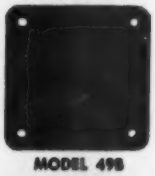


MODEL 17B

All LEWIS thermocouple indicators are fully cold-end compensated, magnetically shielded and are available for use with iron-constantan, copper-constantan or chromel-alumel thermocouples in all standard ranges for the thermocouple material used. A few typical ranges are listed below.

MODEL 17B, 2¼" case to AND 10401
—50 to +300°C Cylinder Temp. (AN 5536-1A or T1A)
—50 to +300°C Bearing Temp. . . .
0 to +1000°C Exhaust Temp.

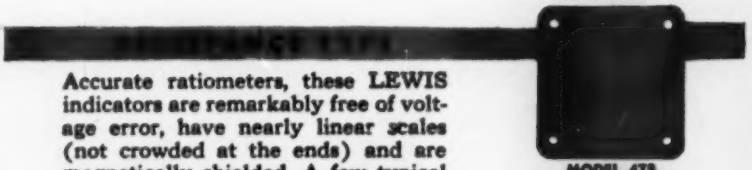


MODEL 49B

MODEL 49B, 1⅞" case to AND 10403
—50 to +300°C Cylinder Temp. . . .
0 to +1000°C Exhaust Temp.

MODEL 76B dual, 2¼" case to AND 10401
—50 to +300°C Cylinder Temp. (AN 5536-2A or T2A)
—50 to 300°C Bearing Temp. . . .
0 to +1000°C Exhaust Temp.

MODEL 76B



MODEL 47B

Accurate ratiometers, these LEWIS indicators are remarkably free of voltage error, have nearly linear scales (not crowded at the ends) and are magnetically shielded. A few typical ranges are given below. Not shown is Model 46B, 2¾" single.

MODEL 47B, 1⅞" case to AND 10403
—70 to +150°C AN 5790-6 or AN 5790T6
0 to +125°C Oil Temp. . . .
—50 to +50°C Air Temp.

MODEL 77B dual, 2¼" case to AND 10403
—70 to +150°C AN 5795-6 or AN 5795T6
+30 to +230°F Oil Temp. . . .
+100 to +300°C Cylinder Temp.

MODEL 77B

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the Flying Atar uses jet blast deflection to alter direction. Company plans to convert the rig into a Coleopter complete with annular wing. Pilot's cockpit with tip-up seating arrangement is being installed. Up to now the rig has been radio controlled from the ground.

Last June Snecma set up a new division which will work with the French Atomic Energy Commission on the development of an atomic airplane engine. Company says it "probably will not work along the same lines as the Americans."

Missiles are still pretty much in the development and testing stage. Insufficient funds is the bottleneck. Only air force operational missile is the 420 lb. Matra air-to-air unit which is equipped with proximity fuse and guided in flight.

Another air-to-air missile, similar but lighter than the Matra, is the Snecma 5103. Also in the pre-production stage are two ground-to-air missiles, the SE 4300 and the Parca, both radio-controlled missiles with 2,000 lb. take-off weight. Tests on the French high altitude research missile, the Veronique, were hampered by lack of funds. Veronique measures 24 ft. and has a gross weight of 1.5 tons. French have reached 90 mi. with the missile, are hoping to reach 137 mi.

Sud-Est Merger

Biggest news over the past year for the French airframe industry was the sudden merger of Ouest Aviation into Sud-Est Aviation. The two big state-owned firms will be officially combined in March under the new name of Sud Aviation. Sud Est, the largest of the French builders, employs 12,000 workers in four plants. Ouest Aviation operates five factories with 10,000 employes. Merger leaves only one other nationalized airframe company, the Nord concern (8,000 employes).

Top man in the new complex will be Georges Hereil, Sud-Est president, who thus will control most of the industry's productive capacity.

The first important shake-up in the industry since the middle 1930s stirred very little interest in the public press or in the National Assembly, which approved it without debate. Some industry sources complain that the industry won't benefit, that the merger will remove too much competition. Hereil thinks otherwise. He looks on the combination as a means of streamlining the industry's limited capacity.

One thing Hereil would like to get done is the selling of the company's Caravelle jetliner. Sud-Est opened a New York office to push North American sales prospects and to prepare for a three-month tour of the medium-range Caravelle beginning in April.

Mark I version of the aircraft is

equipped with Rolls-Royce Avon RA. 29 engines. But company is designing a larger version aimed at more speed and capacity plus increased range. This Mark II version, which would remain in the medium-range class, will be powered by the 16,000 lb. thrust Rolls-Royce Conway by-pass engine. Only Air France has bought the Caravelle and will take delivery of three in the fall of 1958. It ordered 12 with an option on 12 more. Air Algeria has announced its intention to buy three.

Sud-Est is also pushing its helicopter activities. It signed a license agreement with Sikorsky under which it will build most of the S-58s on order by the French military. Production of its own Alouette II, of which 200 have been ordered by the three French military branches, has just shifted into high gear at the company's Courneuve plant near Paris. Monthly rate is nearing 15. The five-place Alouette II is powered by a 1,400 hp. Turbomeca Artouste II gas turbine.

Several Alouettes were sold last year in Portugal, Sweden, and Venezuela. Sud-Est also is developing a Super-Alouette (SE-3200) of which two prototypes have been ordered. Reportedly it will be powered by three Turbomeca engines and probably will carry between 25 and 30 passengers.

Baroudeur Project

Sud-Est's Baroudeur, experimental tactical fighter which takes off and lands on skids, still hasn't found a buyer. Generally understood to be on the shelf, certain renewed NATO interest may bring the project back.

Ouest Aviation is just getting its three-version Vautour off the production line. Initial deliveries are being made on the attack and all-weather versions. Third version is the bomber. The recent cutback in the original order for 360 Vautours probably will hit the bomber version hardest. Vautour is powered by two Snecma Atar jets and is supersonic in a slight dive.

A Vautour derivative, a twin-jet prototype designed to break into the heat thicket, will have considerable range and highly perfected radar equipment.

Ouest's Djinn helicopter, ordered in quantity by the military, is just coming off the production line. Several are being tested by the French Army in Algeria and by the American Army in the U. S. Djinn uses a Turbomeca Paulouste developing 529 lb. thrust to provide compressed hot air to a two-blade rotor with tip ejection nozzles.

Nord is mainly occupied with its Noratlas 2501 twin-engine cargo aircraft. In addition to substantial military orders and some commercial sales, the company has signed a license

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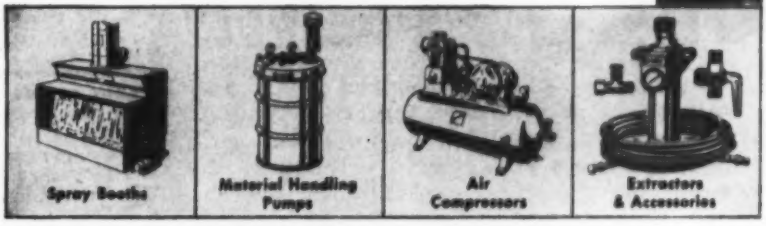

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with German interests under which 137 Noratlas will be supplied to the West German air force. First 25 will be built by Nord, the rest by German interests. New version of the Noratlas (2506) will be fitted with slotted flaps and adjustable landing gear.

Dassault's plane factories are producing the last of the Mystere Is and Mystere IVAs, the former for the French air force and the latter for both French and foreign air forces. India ordered 100 Mystere IVAs and Israel took delivery of several dozen. Production of the supersonic Super Mystere B2 is just getting underway.

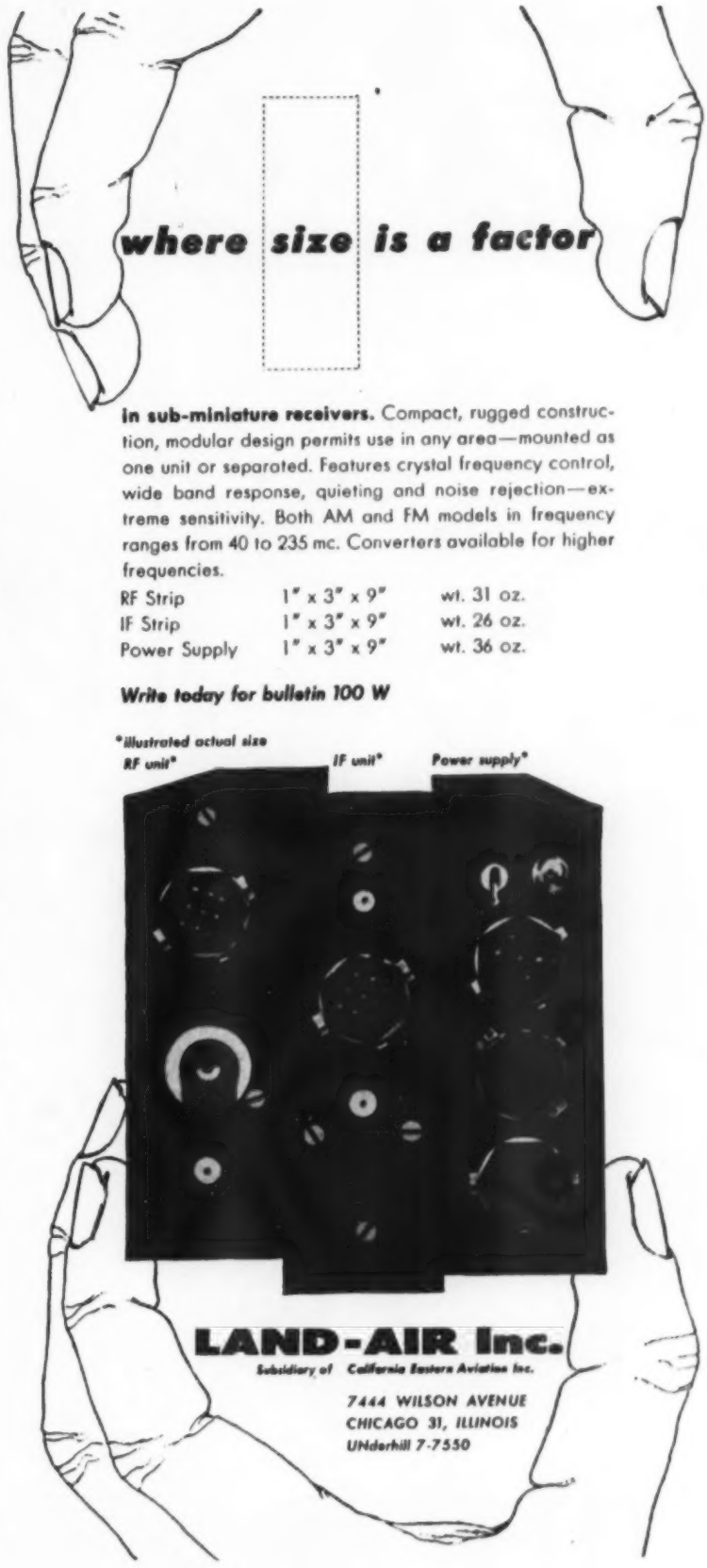
Mach 2 Bomber

Besides Etendard and Mirage flying prototypes, Dassault is studying designs for a supersonic jetliner and, perhaps more seriously, a Mach 2 supersonic bomber. The bomber reportedly would weigh 20 tons and would be powered by two Atar turbojets. A delta configuration is being considered. On the engine front, Dassault has a 3,000-lb. thrust jet under development.

Fouga's CM-170 Magister jet trainer achieved considerable foreign success during the year. Germany ordered 382, of which the first 22 will be built in France. Grumman Aircraft and Engineering Corp. took an option on the U.S. manufacturing rights. The CM-175 naval version flew last summer. French navy has ordered two prototypes. In November, Fouga flew its CM171, the Makalu experimental plane which is being used to test Turbomeca's new 2,500 lb. thrust Gabizo. On one test the Makalu climbed to 40,000 ft. in 9 min. 20 sec. from brake release.

Breguet flew its 1050 Alize anti-submarine aircraft last fall. Navy ordered 100, may order 20 more. Powered by a Rolls-Royce Dart 7 turboprop engine, the Alize carries a crew of three and is designed for carrier operation. Company also is readying two versions of its light-weight fighter, the Taon, for early flight. The 1100 will be powered by two Turbomeca Gabizo engines. The 1001 Taon will take a Bristol Orpheus. Breguet also is producing for the air force 15 BR 765s, a military version of its 763 Provence transport.

Morane-Saulnier signed a contract with Argentine government for the delivery of 48 of its twin-jet Paris liaison aircraft. Order can be increased to 100. Assembly will take place in the Argentine state-owned plant at Cordoba. Argentina also ordered 10 Broussard liaison aircraft. Max Holste, builder of the Broussard, had orders for 354 by year-end. The company also is developing a 'Super-Broussard,' a light transport capable of carrying from 14-17 passengers. The Broussard on order is a high wing, five-place aircraft powered by a Pratt & Whitney R985 engine.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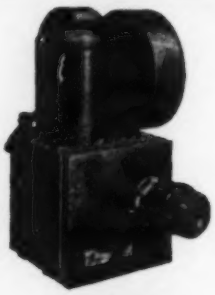

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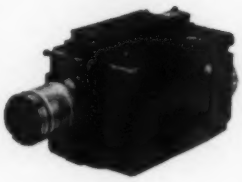

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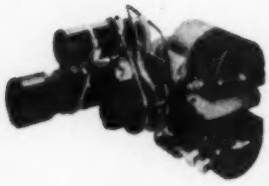

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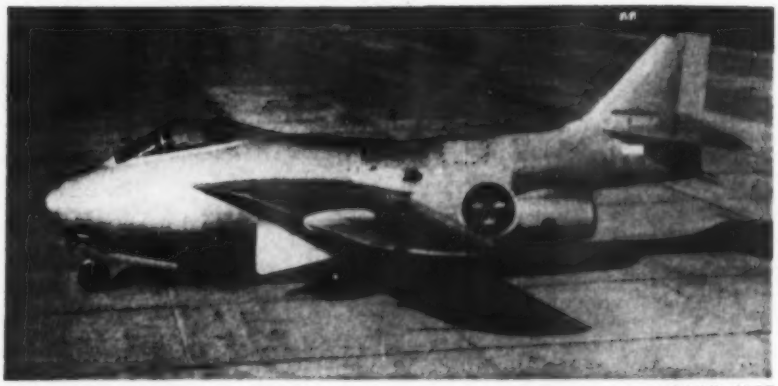
SAAB A32 LANSEN

Saab Output High, Backlog Sets Record

Stockholm—Swedish aircraft industry is busier than ever. At the Saab Aircraft Co.—Sweden's only airframe manufacturer—the backlog of orders is reported to be the greatest in the company's history.

Since the problems in connection with the conversion from J 29 to A 32 Lansen production have now been overcome, deliveries of the latter type are running smoothly. A substantial number already has been delivered and this transonic two-seater is becoming the mainstay of the Royal Swedish Air Force's tactical force.



SAAB J29F

Last month the first J 32B all-weather and night-fighter version of the Lansen made its maiden flight. Differing from the A 32, it has a more powerful Rolls-Royce Avon engine, enlarged Swedish-developed afterburner, new armament and new navigation and fire-control equipment. The J 32B is intended to become the standard night fighter of the RSAF. A reconnaissance version of the Lansen is also to be produced.

The supersonic Saab 35 Draken single-seat all-weather jet fighter was ordered into quantity production in 1956.

Three prototypes are now on flight test. This fighter will eventually replace the J 29. A two-seat dual control trainer version is to be built. The A 32 Lansen has also been equipped with dual controls for use as an advanced trainer.

Saab is converting a large number of J 29B fighters into J 29F, featuring a Swedish-developed afterburner that doubles rate of climb and a modified wing for higher Mach number.

Saab also produces a new series of Saab-91 Safir trainers. An order for 25 Safirs from the Norwegian Air Force is being executed and prospects are good for additional export orders.

Saab's total employment continues to rise and now exceeds 7,000 as against a little over 4,000 in 1950. Considerable expansion of the company's facilities is planned. In 1956

In air-foil sections, strength, accuracy and smoothness are of primary importance. These characteristics, plus a minimum of machining, are offered by this Antioch Process missile fin casting. The alloy: A-356. Tolerances of ±.010" in thickness and .020" T.I.R. on flatness are held in production. Surface finish, as cast, is better than 125RMS. Test bars machined from heavy hub section have minimum ultimate strength of 36,000 psi and elongation of 11%.

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a new factory was built at Jönköping for the apparatus and equipment division, while another was acquired in nearby Husqvarna for the same purpose. Several important new building projects are well under way at the Linköping main establishment.

Jet engine production at Svenska Flygmotor mainly includes the RM 5, a Swedish version of the Rolls-Royce RA 7 Avon, delivering 8,000 lb. thrust (10,000 lb. with afterburner). The RM 5 is used in the J 32A all-weather fighter-bomber. Flygmotor has also started production of the more powerful RM 6, which probably corresponds to the Rolls RA 14 Avon. This 10,000-lb. thrust engine is used in the Saab 35 Draken supersonic fighter and most probably in the J 32B night-fighter version of the Lansen. The RSAF and Flygmotor have collaborated on a Swedish afterburner for this engine.

Defense Cuts

With defense's share of total government expenditure having dropped from 25% in 1953 to 21%, RSAF representatives view with concern air force appropriations under the 1957-58 state budget. Although showing a rise of $7 million to $149 million, appropriations fall short of air force requirements by $17 million. RSAF's $1,000 million plan for 1957-1964 is now cut by $290 million and the ten-year plan outlined in 1954 by Gen. Nils Swedlund, Supreme Commander of Sweden's armed forces is being undermined. Instead of a 22% overall increase, RSAF strength will be reduced 15%. This would eventually lead to more than 20% decline in aircraft numbers.

Airpower's role in national defense as a first line to prevent an enemy from gaining air supremacy above Swedish territory and to cooperate with land and sea forces in warding off a possible invasion still remains undisputed. This task can only be fulfilled by an air force technically on a par with that of a presumptive enemy, the RSAF maintains. Should the air force, through shortage of funds, be forced to choose between either (1) maintained number of aircraft with reduced quality or (2) reduced number of aircraft with maintained quality, there seems to be little doubt it would prefer the latter, even though this would mean leaving part of Sweden's extended air frontier—equaling half that of NATO's entire European front—without sufficient cover.

One serious consequence of government undercutting of air force demands is the delay in building new air bases. The expansion of radar counter-measures is also likely to be postponed.

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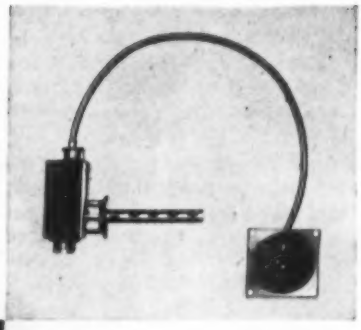

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You can't shrink the pilot
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New transceiver control box reduced to one-fifth former size

The cockpit of a modern fighter plane is packed as tight as a filling in a hollow tooth. As more and more electronic equipment is added to the plane's complement, each new device must fight for space on and behind the instrument panel or console. Now Admiral, maker of the famed AN/ARC27 transceiver, has designed a control box that "moves over" to make room for other needed equipment.

Heart of the new control is an ingenious "mechanical memory" drum that selects any one of 20 preset frequencies with a single knob. Another knob controls three coaxial switches designed by Admiral so the pilot can manually select any of the transceiver's 1750 frequencies. This single compact unit will be universally employed to replace any one of 15 currently used control box combinations. It occupies as little as one-fifth the space and also reduces weight up to 80%.

Here is another instance where Admiral initiated and perfected an important advance in the science of military electronics. Inquiries are invited regarding Admiral's capabilities and production capacity for electronic or electro-mechanical equipment.

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ENGINEERS: The wide scope of work in progress at Admiral creates challenging opportunities in the field of your choice. Write Director of Engineering and Research, Admiral Corporation, Chicago 47, Illinois.

Swedish air force consists of 30 day-fighter squadrons, 3 night-fighter squadrons, 12 fighter-bomber squadrons, 5 reconnaissance squadrons, 1 air base corps and one search and air-rescue unit.

RSAF strength is approximately 1,200 combat aircraft.

Of the day fighter squadrons three were equipped with Hawker Hunters (designation J 34) in 1956. Three more will be equipped with this aircraft this year. The Saab J 29 is in service on the remaining day fighter squadrons, with increasing numbers of J 29Fs coming into service.

The three night fighter squadrons are equipped with de Havilland Venoms (J 33), to be replaced by the new Saab J 32B. Re-equipment of at least three day fighter squadrons with night fighter aircraft is planned but will probably have to be postponed a while for lack of funds.

Six fighter-bomber squadrons have been equipped with A 32 Lansens and the remaining six are to follow. They now use the A 29 fighter-bomber version of the Saab J 29.

It seems probable that the J 35 Draken fighter—expected to usher in the delta age in Swedish military aviation by 1959—will have fighter-bomber and reconnaissance development.

Whether the J 35 Draken will be succeeded by another piloted fighter or by a guided missile is still unknown.

An interceptor missile has been under development for several years. Development costs have been estimated at about $6 million.

Last year's order for a number of Australian Jindivik 2 targets indicates that the RSAF is ready to test an air-to-air missile in a not too distant future.

It also is assumed that the RSAF will soon have an air-to-ground or attack missile operational. It was stated at the end of 1952 that such a weapon could be expected about the time the A 32 would come into service. Lansen deliveries started at the end of 1955.

Politics Stirs Argentine Rivalry

Buenos Aires—Vigorous rivalry between the air force, army and the naval air arm marked Argentina's first post-revolution year.

Since the country has a provisional government, supported by an often uneasy alliance of navy, army and air officers, the inter-service rivalry has strong political overtones.

Navy now appears to have the upper hand in the national air race. It recently purchased 20 used Grumman F9F Panther jets at $18,500 each from the U.S. This followed closely upon the cancelation of an air force order for 36 Sabre Mark VIs from Canadair Ltd. The cancelation was forced when the Central Bank did not give the air force foreign exchange for the purchase. Not a single plane was bought for the air force during 1956.

The air force still has a strong edge in number of trained pilots, approximately 450 to the navy's 245.

The air force has contracted for 90 Beech T-34 Mentor trainers, over a three year period, 75 of which will be assembled at the Cordoba factory, IAME. The Beech contract was the first licensing and technical assistance agreement between a U. S. manufacturer and the Argentine government since World War II. Negotiations are going on for a number of French Morane-Saulnier aircraft to be assembled at the same plant.

The IAME works employs 8,500 people. In the past it manufactured various home-made planes such as the IA 35 and the prototype delta-winged IA. 37 and 38. If the air minister has his way, IAME will be the nucleus around which a small aircraft industry will grow.

There is an immediate Argentine market among cattle breeders, air taxi services, industrialists, etc. for 200 light planes.

The Argentine air force, army and navy are operating a mixture of German, British, Italian, U.S. and some home-made aircraft. This roster includes: Gloster Meteor, Fiat, Calquin, Avro Lincoln, Lancaster, Beechcraft, Viking, Dove, DC-3 and DC-4, PT-13 and PT-19. The largest group of a single type are Gloster Meteors. Out of an original purchase of 100, the air force has 70 left, of which 45 are operable.

The U. S. last year offered the Argentine air force F-84 Thunderjets at $30,000 each. This offer was not accepted. It is said the Argentines thought this plane too hot for them to handle.

Navy acquisition of 20 Panthers is expected to be supplemented by an additional purchase of 14 to 16 more of the same type. Other recent navy purchases were 10 F4U-5 Corsairs from Chance Vought, with the possibility of acquiring 12 more, and one $250,000 army-version Sikorsky S-58 12-passenger helicopter scheduled for delivery in April or May.

Available planes are shifted about amongst the three services at such a rate that it is often very difficult for public relations officers in any service to state with certainty the number and kind of units his own branch has in operation.

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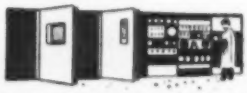

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Australia Stalls Air Decisions

Melbourne—Uncertainty was the primary factor for both RAAF and the Australian aviation industry in 1956, but long postponed vital decisions regarding future air policy are expected in 1957.

Basically, the problem is twofold and interdependent:

• **What aircraft** should be ordered for RAAF to maintain its position as a compact but highly up-to-date air force.

• **What to do** with the Australian aviation industry.

Since 1950, about 400 aircraft have been delivered to the RAAF. During this period orders placed with Australian manufacturers included 90 Avon-Sabres, 30 Vampire fighters, 104 Vampire jet trainers, 62 Winjeel basic trainers, 48 Canberra medium bombers. Overseas purchases include 101 Meteors, four Canberras, 12 Neptunes, two Metropolitans for VIP transportation.

Some of these planes have been lost and some remain to be delivered during 1957. Now the RAAF comprises fewer than 15,000 officers, men and airwomen of the WRAAF. Its No. 1 Bomber Squadron is based on Singapore (since 1950) and uses obsolete Lincoln bombers. It will be withdrawn shortly and re-equipped with Canberras.

Either No. 2 or No. 6 Bomber Squadron, both re-equipped with Canberras, will go to Penang as part of Australian contribution to strategic reserve of SEATO. RAAF's construction squadron is building a modern jet aircraft base at Butterworth, Malaya, where in addition to Canberras RAAF will have Avon-Sabres.

Fighter squadrons in Australia are being re-equipped with Avon-Sabres as soon as delivery is made from Commonwealth Aircraft Corp.'s plant in Melbourne.

During 1956, the RAAF changed its basic trainer, abandoning Tiger Moths and concentrating on 3-seater locally-designed and produced Winjeels. The total order of 62 will be completed before the end of 1957.

RAAF Wants F-104, C-130

RAAF's big problem is future equipment. Despite considerable non-expert pressure, it still wants the F-104 and C-130 and it wants them badly. Constant rumors that it may select a U.K.-made plane have been answered by RAAF's official spokesman:

"The F-104 and the C-130 are the only two new aircraft which we desire at the moment".

The C-130s are urgently needed, as the obsolescent Dakotas have ended their useful life.

But RAAF can only advise and the decision to buy must be made by the Government which has been postponing the decision for months.

RAAF has now lost its enthusiasm for big bombers and if any are bought, they certainly will be British, and then only a few. An influential section of both Government and RAAF is strongly opposed to any purchases of British equipment and insists that RAAF has to standardize on U.S. equipment, which will be the only equipment available to it in case of large-scale conflict.

RAAF says there are no plans to buy helicopters.

RAAF's Aircraft Research and Development Unit at Laverton, Victoria, is working in conjunction with the Department of Supply on a project to solve certain basic problems concerning a delta-winged aircraft. An Avro 707 is used in the experiments.

Australian missile development is lagging badly. The Government has put all its hopes (and a lot of money by Australian standards) on British development of missiles. After some years it is freely acknowledged that the progress has been highly disappointing and that in case of need, Australia will have no missiles to use in defense or attack. Nothing useful can be bought or ob-

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Henry Rempt (center), head of the Electronics and Armaments Systems Division, discusses advanced data transmission and data handling systems for A.E.W. aircraft with Systems Engineer Bruce MacDonald (left) and Dominick Amara, head of the Advanced Systems Dept.

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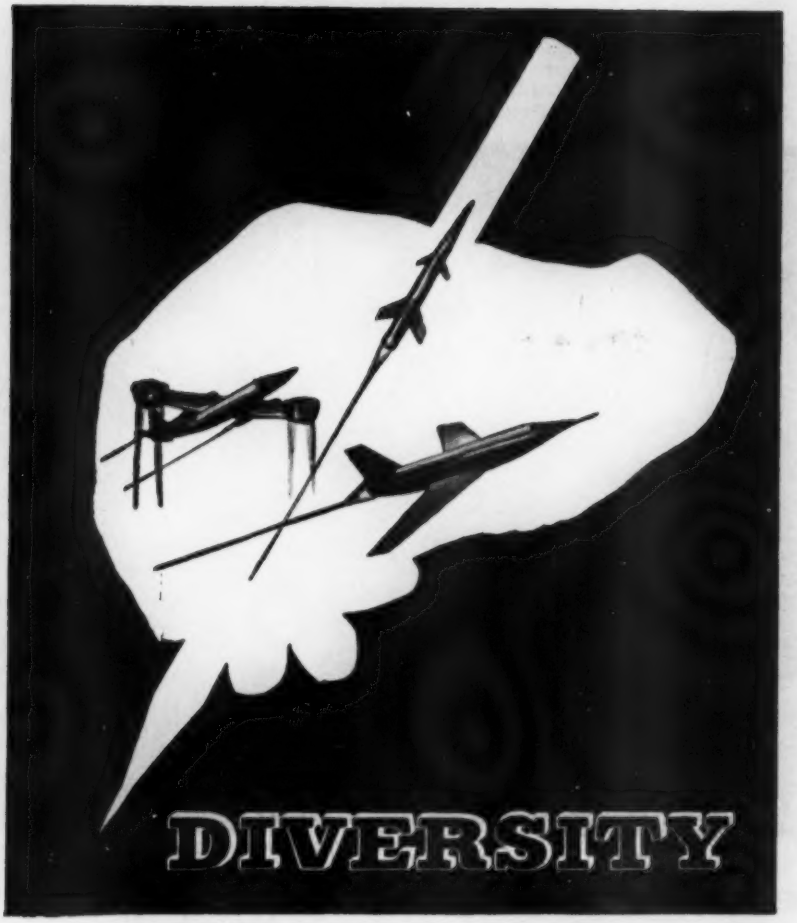

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tained from U.K. and Australians hope that the U.S. will provide them.

Royal Australian Navy's newest carrier, Melbourne, has finally arrived with its complement of Sea Venoms and Gannets plus Sycamore helicopters. Sea Venoms went through a lot of trouble, including a prolonged grounding, and both types have been criticized as obsolescent for a carrier which is one of the most modern of her class afloat.

But RAN has not yet achieved the RAAF's independence and its orders follow strictly Royal Navy preferences. No further additions to its air arm are envisaged in the near future.

Industry Future

Widespread dismissals of employes in the Australian aircraft manufacturing industry occurred in 1956 as existing orders approached completion and no new orders followed. The Government is postponing a decision on the future of the industry or at least two of its most important components, Government Aircraft Factories and Commonwealth Aircraft Corp.

According to unofficial but reliable estimates, a decision to produce F-104s locally will postpone deliveries considerably and the cost may be as much as 300% of the eventual cost of purchase of F-104s from the U.S. Moreover it is known that a good proportion of the equipment will have to be purchased in the U.S. because some secret equipment will not be available for manufacture under license. This year will see a Government decision as to the future of Australian aviation manufacturing industry, but it would be a surprise if the plants are restored to previous capacity production.

De Havilland's Bankstown plant is busily turning out Vampire trainers. In Melbourne the Molyneux company is shortly to demonstrate the prototype of its light helicopter. Several British aviation manufacturers have established themselves in South Australia where they work on missile and experimental problems. Most say their facilities will be used for manufacturing but nothing has been done in this direction.

Experts consider that Australian aviation industry is uneconomical and that the skill and manpower available could be better utilized than in production of standard models available at less cost and quicker delivery from abroad.

RAAF will accept such a decision; in fact it will accept any decision provided uneasiness and uncertainty end.

Its planning has been badly affected by the absence of decisions to be taken by politicians and RAAF is afraid that its state of preparedness for conflict is at a low level. But 1957 should see a firm Government policy and orders for RAAF's future reequipment to maintain its wartime and postwar efficiency.

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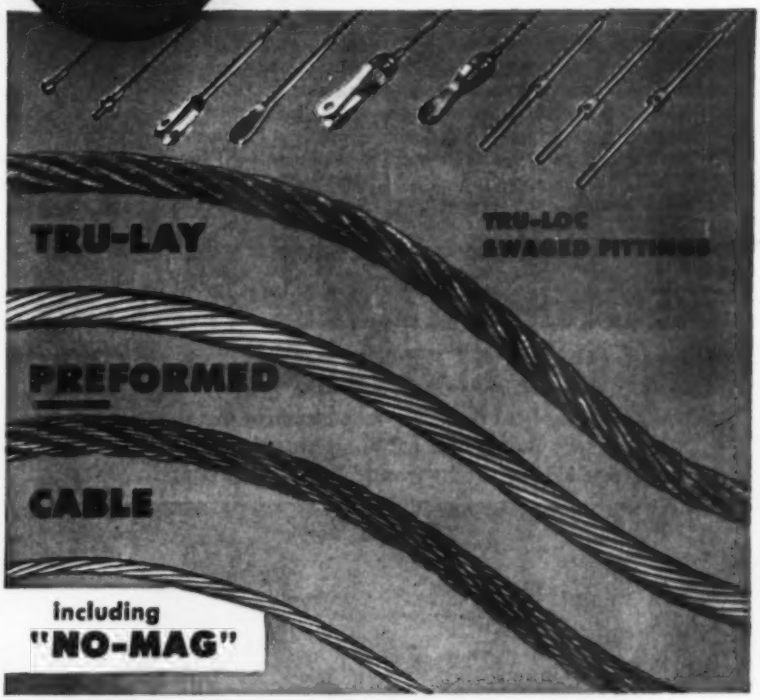

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Belgium Seeks All-Weather Fighter

Brussels—Belgium was able to overcome maintenance problems for its air force last year, but in their place two other problems have emerged:

- Lack of a satisfactory all-weather interceptor.
- Shortage of pilots.

Belgium has the money to buy an all-weather airplane, but insists on a two-seat airplane and radar fire control. This first requirement knocks out the F-86D, which Belgium could obtain through MDAP.

French Vautour is not in series production; lack of radar fire control eliminates the British Javelin. Belgium has been offered the Canadian CF-100, but complains that the U. S. will not release the radar equipment.

Belgium feels this problem is a common one throughout Europe where climate may necessitate an all-weather aircraft 250 days of the year.

Belgium, which has an Air Force of four Air Defense Wings, two Tactical Wings and a Transport Wing, has only about 400 operational pilots. This averages little over one per airplane, compared to the NATO standard of 1.5.

Sabena Belgian World Airlines, foreseeing bumper traffic for the 1958 Worlds Fair, offers 2½ times the pay of a sergeant pilot, but is having trouble itself in finding pilots.

Belgium has only one aircraft of her own. This is the small S. V. 4 used as a primary trainer. It is a biplane powered by a single Renault 140 hp. engine, and made on a very small scale by the designers, Stamp & Renard (formerly Stamp & Vertongen) at Evere, near Brussels. It is also built under license in France.

Hunter Production

The only other manufacture in Belgium is that of the Hawker Hunter under license. Its Rolls-Royce Avon engine is made by the Fabrique Nationale d'Armes de Guerre at Herstal, near Leige, manufacturing both for the Belgian and the Dutch air forces. The same two air forces are served by the Fokker plant in Holland, which makes the wings. Fuselage is made by the Belgian subsidiary of Fairey Aviation Co. at Gosselies near Charleroi. The undercarriage and various parts are made by SABCA (Societe Anonyme Belge de Construction Aeronautique), and there are assembly lines at Fairey and at Fokker.

Belgium's one air force transport wing is now reduced to two squadrons one of which, the communications squadron, is not earmarked for NATO. The four Air Defense wings are stationed at Chievres, Beauvechain, Brusthem and Bierset, and two Tactical wings, which form part of the (Anglo-Belgian) 83rd Group 2nd Tactical Air Force, are based at Florennes and Klein Brogel. The Tactical wings are now fully equipped with F-84Fs (Thunderstreaks) through MDAP. For the Air Defense wings, VII (Chievres) is now fully equipped with Hunters, which are beginning to replace the Meteors in the other wings.

Component Flow

The 1955 difficulties over maintenance were overcome, partly by improved supply of components through MDAP, partly by big extensions to the SABCA workshops where the work is done under contract.

No guided missiles are made in Belgium. It is understood some will shortly become available (through MDAP), but the question of whether they should go to army or air force is only now entering the talking stage.

During 1956 the Chief of Staff of the Belgian Air Force, General Leboutte, retired under the age limit. He was replaced by General-Major Frans Burniaux. The total air force strength is around 1,200 officers and 20,000 other ranks.

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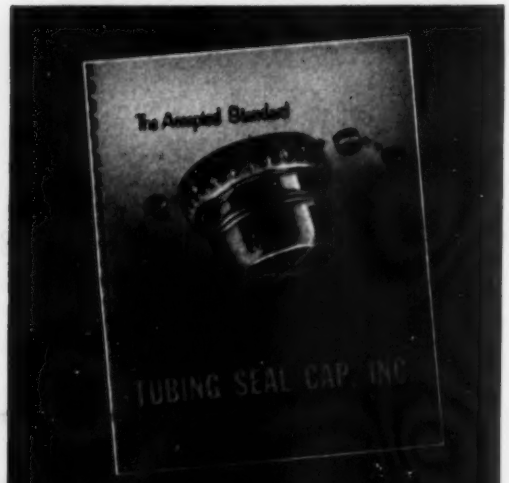

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Brazil Interested in New Transports

Rio de Janeiro—Aircraft production in Brazil is in the embryonic stage. Fokker has a plant in Rio working on a contract with the Força Aérea Brasileira (Brazilian air force) to turn out about 100 basic training planes this year. Fokker also intends to start production of its jet trainer in Brazil, but has not closed the contract with the government as yet. Production is expected to begin in 1958 or 1959.

Brazil plans to have a 600-plane air force in 1957. This will be about a 15% increase in size over last year and would put Brazil in third place in the hemispheric air forces.

Brazilian air force's development this year will tend toward multi-engined aircraft, especially in the transport and rescue lines. However, the air force is studying purchase of Canberra light jet bombers from England this year or next. If Brazil buys the Canberras, it will probably form one Brazilian group (36 aircraft).

Several groups of B-17s, mostly used for rescue work and transport, B-25s and A-20s are operational and Brazil will probably get one group of B-26s this year from the U.S. Plans have been made also to get one squadron (12 aircraft) of SA-16 Albatrosses this year for air-sea and jungle rescue work. An unspecified number of P2V Neptunes for patrol and rescue work will be received by 1958.

Last year, Brazil received 12 C-82 cargo and troop transports from the U.S. and hopes to get more this year and next. Air force commanders also are studying a plan to be worked out with the U.S. Air Force to obtain some four-engined transport planes, Constellations, perhaps, or DC-6As.

Air force has about 120 transport planes now, including C-47s, C-45s, C-82s, some B-17s and a few C-46s for carrying gasoline in drums, hopes to double this fleet by the end of 1958.

At the end of last year, the Correio Aereo Nacional (Brazil's version of MATS which serves as a jungle airline) opened a new, direct route from Rio to Manaus with stops at new jungle bases in Matto Grosso and Pará States. The coastal runs and long-range routes in the interior by the end of next year will probably have four-engined equipment for cargo.

President Juscelino Kubitschek, Air-Minister Fleiuss and other VIPs will start riding in style this year with two new Vickers Viscount 770Ds purchased from England for medium-range domestic use and for official use in flights to other South and North American countries.

As far as single engine fighter aircraft are concerned, the air force seems to be satisfied with what it has: 72 Gloucester Meteor jets, purchased several years ago from England on a special deal in exchange for cotton, and varying numbers of Republic Thunderbolts and other World War II U.S. aircraft.

Brazilian navy's purchase of the aircraft carrier Vengance from England at a reported $22 million might force a change in air force plans, however. An iron-clad Brazilian law gives the air force responsibility for supplying pilots, crews and aircraft for the aircraft carrier.

Air force officials would prefer to standardize with U.S. planes and engines, but navy officials tend to prefer British aircraft for the British warship. Both agree that 36 planes probably will be purchased for the new carrier, called the Minas Gerais.

U.S. has an Air Mission in Brazil which works with the Brazilians in deciding what planes they will need for defense and transport. A U.S. mission official said that the United States Air Force delivered four T-33 jet trainers to Brazil in December, 1956, and that Brazil will probably receive several C-119 and C-123 cargo planes for the transport division. Brazil also has 12 S-55 helicopters on order for its jungle and sea rescue squadron.

Enigma Left by Air Fighting in Egypt

Cairo—Status of the Egyptian air force is uncertain, the British and French having claimed destruction of 150 airplanes on the ground during the Suez fighting, the Egyptians countering they lost no planes on the ground and only eight in the air.

Unofficial figures placed the strength of the Egyptian air force before Suez at more than 400 aircraft, half of them Russian types. This figure included 200 MiG-15s and MiG-17s and 40-70 Il-28 twin jet bombers.

Egyptian claims that dummy aircraft absorbed most of the ground attacks were backed up with an official photograph showing a MiG-15 "dummy" being moved at Almaza Airport. Minute detail of the dummy, however, including control surface hinge lines and a plug for the tail pipe tended to knock down the Egyptian claims (AW Nov. 26, p. 37).

Egyptian failure to press home the few interceptions made, or to use its air force at all, puzzled British and French attackers. One explanation is that Egyptians were having trouble training pilots to handle the sudden influx of high-performance airplanes.

A British observer in Egypt before

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the fighting noted that there was plenty of flying of the MiGs, but apparently by Central European pilots. There were indications that the Egyptians had frequently overrun the 9,000 ft. runways at Abu Sueir Airfield in landings.

French believed that most of Egypt's Il-28s were evacuated immediately by Russian pilots to friendly airfields, possibly in Syria.

Egypt reportedly was to receive more Russian fighters this year, but doubts have been expressed whether the Russians will want to continue giving the Egyptians military planes. There is no combat plane or missile production in Egypt, and no research and development. Some training planes are assembled in government war factories.

Besides its Russian military types, Egypt also uses British Vampires and Meteor jet fighters acquired earlier, and C-46 and C-47 transports.

India Moves Into Military Production

New Delhi—Significant aviation development during the year concerned the expansion of the state-owned Hindustan Aircraft Ltd. (HAL) at Bangalore, which now has an agreement with the British Folland Aircraft Co. and Bristol Aero Engine Co. to manufacture Folland Gnats and the Orpheus jet engine.

HAL also engaged a team of German experts, headed by Dr. Kurt Tank, to design and blueprint the first Indian jet fighter.

To HAL's own credit is the all-India-made HT-2 trainer, flown and demonstrated through Southeast Asia last year. Ceylon, Malaya, Indonesia and Thailand have placed purchase orders. HAL, which up to 1955 was doing only an overhauling job, mainly for the Indian Air Force, began production of Vampire jet trainers in 1956.

The Indian Air Force's main achievement last year was the linking of India to Tibet, a new air-route which crosses the Kanchenjanga Massif. The IAF used the Meghdoot—the Ilyushin transport presented to Premier Nehru by the Russian government last year.

Switzerland Strives For Its Own Fighter

Geneva—Switzerland, to the tune of much public criticism, went ahead last year with its attempt to build an all-Swiss jet fighter. It canceled a $25 million order for 40 French Mysteres to build domestically another prototype of the P.16 at a cost of $5 million.

The first prototype of the Armstrong-Siddeley Sapphire powered fighter flew twice two years ago, but ran into brake trouble. The second airplane, if it meets schedules, will not be ready until 1958.

Switzerland, with high mountains and deep valleys strewn throughout its 200 mi. length, wants a highly maneuverable fighter. The work was assigned by the government to the Flug-und Fahrzeugwerke A. G., Altenrheim.

De Havilland Ghost 48 Mk. 1 engines for 150 domestically produced Vampires were built by Sulzer Bros. at Winterthur. Aircraft assembly is carried out at the Federal Aircraft Factory at Emmen.

Swiss air force strength includes 100 F-51s bought in 1948, 75 Vampires bought from England, 100 Vampires built domestically with imported engines, and the 150 entirely built in Switzerland. A series of 250 de Havilland 112 Venoms to replace Vampires is being built in Switzerland.

Costs of building the engines at home have been about the same as importing them.

GERMAN DORNIER 27

West Germany Rebuilds Luftwaffe

Bonn—West Germany wants to rebuild its Luftwaffe with fast, light interceptors and guided missiles.

German aviation men say they are interested in "F-100 and other types." And Germany has gotten together with France for information on missiles and rockets.

Primary mission of the Germany Luftwaffe will undoubtedly be the interception of planes striking at German territory from the East. While New York City may get as much as two and one-half hours warning of an enemy strike, a city like Frankfurt am Main may get only two and one-half minutes notice. Germans feel therefore that their most urgent need is a very fast, very light, fighter equipped with RATO which can challenge an invading enemy strike force on extremely short notice and can operate from very small airfields.

Bonn sources state that they are still interested in a blue-print model of a Northrop designed interceptor. Earlier discussion between Northrop and Krupp stalled because of Krupp's hesitancy to reenter the arms field, but interest still exists.

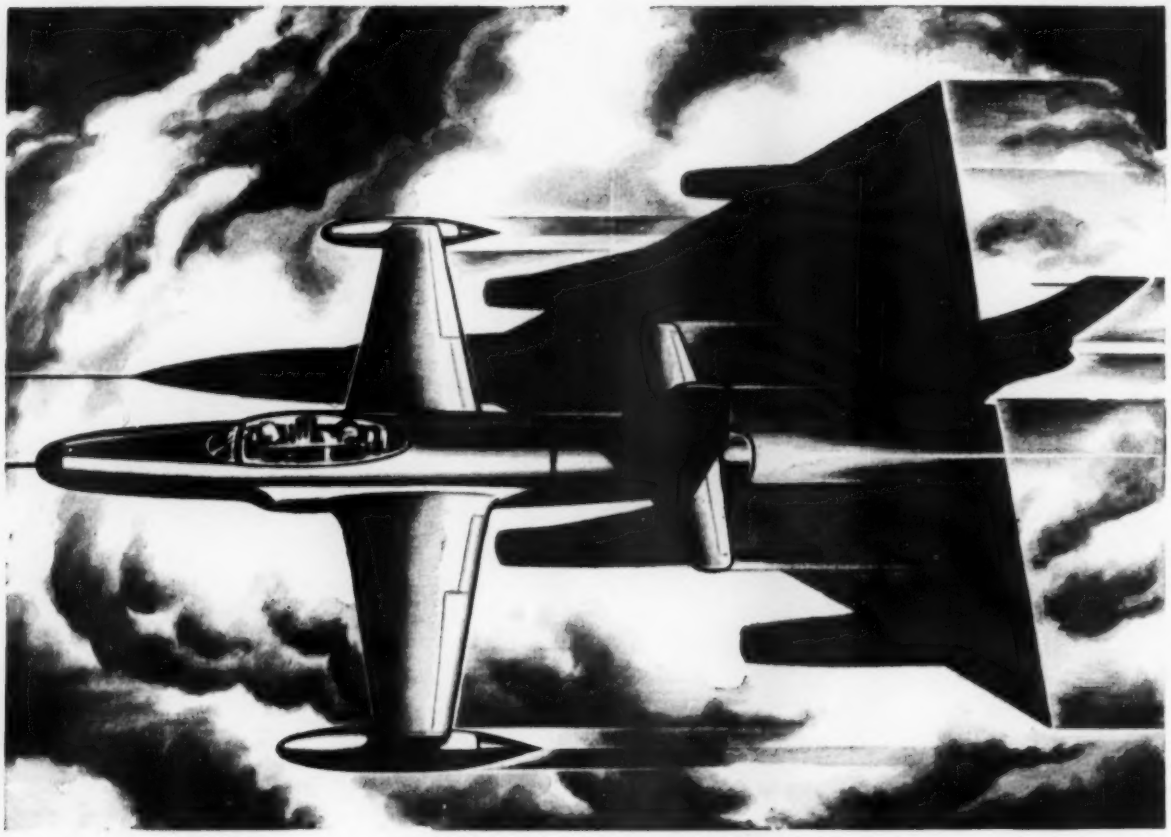
Guided missiles also will play an integral part in the defense of German and NATO territory. The German and French defense ministers reportedly reached agreement to exchange information on guided missiles and rockets.

U.S. and Canada rank first and second as supplier of aircraft to the Federal Republic. The U.S. has supplied 1,000 aircraft, including 550 of the F-84F type. These are now being de-mothballed and made ready for operational duties at Weser AG, a Krupp subsidiary near Bremen. The Lemwerder plant of Weser AG has just completed a runway which is 9,500 ft. long and 90 feet wide at a cost of DM 9 million.

Canada gave 75 Sabre Vs and Germany has recently placed an additional order for 225 Sabre VIs. In addition, Canada will train 360 German pilots and an unspecified number of technicians.

Build-up of Germany's Luftwaffe made steady strides during 1956. Lines earlier drawn for the license production of foreign types by four German groups remained rigid. In broad principle, these contracts are:

Flugzeugbau Nord GmbH., compris-



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Months before the Convair B-58 supersonic bomber took to the air, its handling characteristics had been successfully simulated by C. A. L. on a totally different airplane.

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This project is typical of the 160 varied research projects currently active at C. A. L.—stimulating, technically challenging, and professionally significant. Our research program is unusually broad in scope, encompassing such areas as Aerodynamics, Propulsion, Aeroelasticity, Wind Tunnel Research, Flight Research, Aircraft Design and Missile Systems. This broad program, coupled with our policy of assigning each staff member in accordance with his individual abilities and interests, makes it possible for us to offer outstanding employment opportunities to capable and imaginative men.

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ing Weserflug AG (Bremen), Hamburger Fahrzeugbau GmbH., and Siedel ATG GmbH., will build 117 Sncan 2501 Noratlas transports.

• **Focke-Wulf** AF., Bremen, and Engineering Bureau Pro. Blume will build 194 Piaggio 149 training planes.

• **360 trainers** of the Fouga Magister type will be constructed jointly by Messerschmitt AG., Munich, and Heinkel AG, Stuttgart.

• Dornier, Munich, will build 469 DO 27s.

These basic Luftwaffe orders are valued in Bonn between DM 600 million and DM 1 billion.

Dornier and F-86s

Dornier probably will serve the Luftwaffe's F-86Ks while Weserflug AG Germany's F-84Fs and RF-84Fs.

Officials of Orenda recently held discussions with BMW (Bayrischermmotorenwerke) and an agreement which would have BMW repair and service all Orenda engines operating in Germany seems imminent.

Daimler-Benz, Struttgart, will reach agreement with Curtiss-Wright concerning the repair and service of J65 engines This agreement would probably be part of the overall Curtiss-Wright - Studebaker - Packard - Daimler-Benz deal.

Few Test Facilities

As to Germany developing radically new types of planes, the outlook is bleak. There are few test facilities and no wind tunnels of the type required to do advanced work in jets. Naturally, people like Messerschmitt, Heinkel, Dornier have their own development departments but Bonn officials state that industry will concentrate on building small, light, propeller-driven planes. The DO 27 is an example of a Germany developed plane which seems to offer possibilities for the export market.

The Luftwaffe is dissatisfied with presently available helicopter models; no large order for helicopters has been placed by the defense ministry.

Weserflug AG, Bremen, is preparing to assemble and service Vertol H-21s.

The German Research Association for Helicopters is interested in developing a small helicopter which could be maintained without great expense.

Interest is high in the pooling resources with the French aviation industry. Germany would like to be able to make use of French research establishments (which the Germans do not have nor can afford to construct at this time), and the French would undoubtedly like to see a "European aircraft industry concentration," based initially on 'German-French cooperation, which would permit them to more efficiently compete with the American and British industries.

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The above "Team" was capable of producing seven NEW items—from Proposal, to Proto-type Delivery—in ONE year.

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Thomas W. Moore (3), Engineer in charge of Design Research, is experienced in practically every facet of Airborne Electrical Equipment Design with special emphasis on controls. He holds many ingenious patents in aircraft electrical equipment.

Hayes Crapo (4), Manager of Product Design, heads a staff of experienced engineers who follow the design from development to production. His highly regarded experience as Design and Supervisory Engineer involves both AC and DC airborne equipment.

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ROY MARQUARDT, at 39 is the youngest chief executive officer in the aircraft engine business. A graduate of the California Institute of Technology, he was Director of Aeronautical Research at the University of Southern California prior to founding Marquardt Aircraft Co. in November, 1944.

opportunity to grow with the Company

Engineers looking for a company to grow with, should look to Marquardt Aircraft Co. Here is why!

Under the guidance and leadership of Roy Marquardt, an engineer-president, Marquardt has become the undisputed leader in the field of ramjet engines—"the powerplant of the future".

In just twelve short years, the company has grown from one man's idea to an engineering and production facility playing a vital role in national defense.

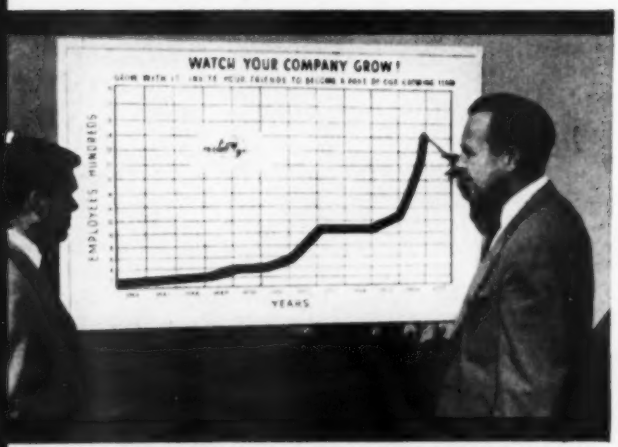
But most important, Marquardt engineers have grown in skill, scope and professional ability along with the company's many exciting and rewarding projects.

Within the next two years, Marquardt will more than double its manpower. Even with this new increase in personnel, engineers joining Marquardt now will have this same opportunity to grow and advance with the company.

For engineers in almost every specialty —from production engineering and qualification testing to advanced research in hypersonic propulsion, new chemical fuels and nuclear energy — Marquardt offers you an opportunity to grow with the company.

FIRST IN RAMJETS — Marquardt is currently producing supersonic powerplants for the Bomarc IM-99 Interceptor missile being built by Boeing Airplane Company.

CONTROLS AND ACCESSORIES — More than a decade of experience with ramjets has enabled Marquardt Aircraft Co. to develop automatic controls for turbo-jet engines.



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● **HOLLAND**

Major Dutch Effort Goes in Friendship

Amsterdam—First of the prototypes of the Fokker F. 27 Friendship, a 32-40 seat twin-engine turboprop airliner for short and medium range operation which made its maiden flight in November 1955, has logged about 325 hrs. in intensive test flying.

Many test flights have been made for CAA and Dutch Air Registration Board. Second prototype has been built, on which an extensive static test program was concluded in 1956. All tests, including pressurization trials, ultimate load bending of fuselage and wings, have been most satisfactory. Static tests have been ended with the intentional breaking of the wing.

The third prototype, which will be the second aircraft for test flying, neared completion in 1956. Its first flight is scheduled early in 1957. This aircraft will be fully equipped with pressurization system and deicing installation.

In the meantime preparations for quantity production are in an advanced stage. The first front fuselage is in an assembly stage. Delivery of the first production aircraft is scheduled for 1958.

The sales prospects for the Friendship are very good and orders received towards the end of 1956, including the short-time options, have passed 100.

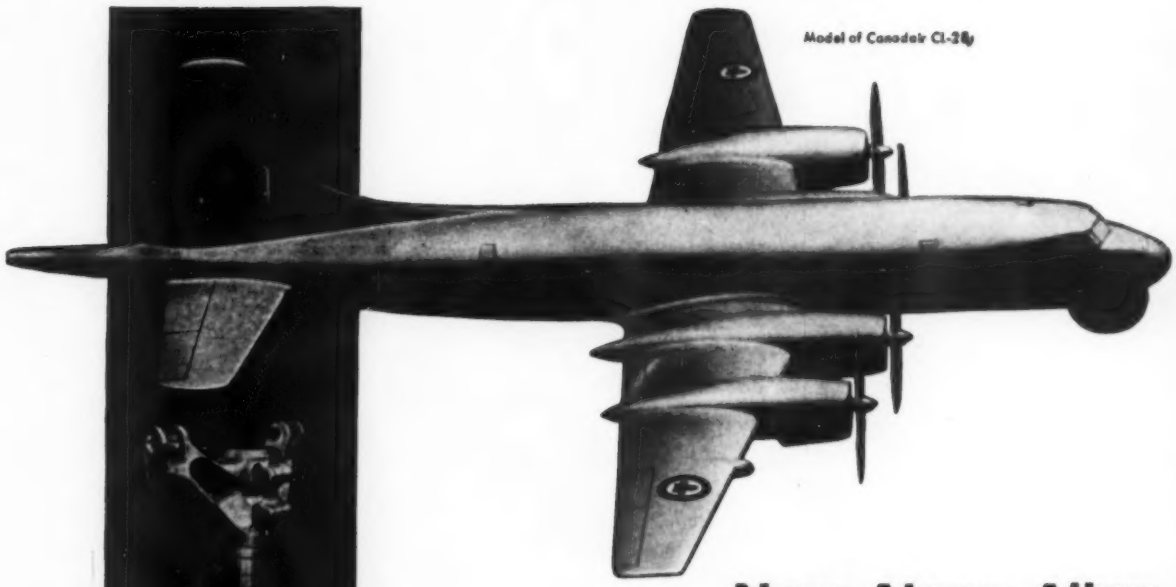
During 1956 large quantity production and modification of Hawker Hunter fighters for the Royal Netherlands and Belgian Air Forces and for NATO made considerable progress. Large major overhaul and repair program of Meteor jet fighters was continued at Amsterdam, while at Ypenburg similar IRAN program on F-84 Thunderjets was performed. Large numbers of F-84F Thunderstreaks and RF-84F Thunderflashes have been processed at the Ypenburg works. In 1956 a number of Dakotas were overhauled.

During 1956 the floorspace of the Fokker factories at Schiphol (Amsterdam) was considerably increased, with new facilities for metal bonding, reinforced plastics, assembly and storage. The total floor space at Schiphol now amounts to 700,000 sq. ft. Total number of employes is near 5,000.

Aviolanda, Papendrecht and Woensdrecht, has largely confined itself to repairs and maintenance for the Royal Netherlands Air Force and Navy and to certain conversions, for example Douglas DC-3s and DC-6s for KLM.

It has manufactured, in cooperation with Fokker, some SAAB aircraft for Sweden, Gloster Meteor Mk. 8s for the air forces and Hawker Hunter Mk. 4 and Mk. 6s for the same forces.

The firm has recently built a new



New Alcoa Alloy

strengthens undercarriage of Canada's biggest plane

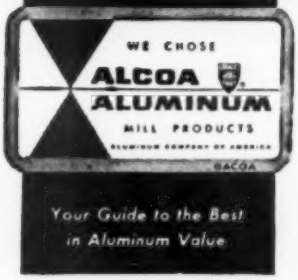
The Canadair CL-28 maritime reconnaissance aircraft will soon go into service with the Royal Canadian Air Force. Developed from the Bristol Britannia class by Canadair, this is the largest aircraft ever to be manufactured in Canada. To strengthen the undercarriage, Canadair selected a new Alcoa alloy, X7079, which meets the Canadian ductility requirement of 4% minimum short transverse elongation.

At the same time X7079 provides a bonus in design allowables which will be especially valuable if Canadair ever wants to increase the weight of the aircraft. The CL-28 has 41 forgings of X7079, many of them made on Alcoa's 15,000-ton press.

The new alloy has higher yield and tensile strengths than its predecessors, particularly in sections over 3" thick. It is also less quench sensitive which means more uniform properties in heavy sections. As a result, Alcoa® has established guaranteed properties in die and hand forgings up to 6" thick in the—T6 temper.

In general, X7079 behaves even better than Alcoa alloy 7075. It has more uniform machinability and has the same excellent resistance to stress corrosion cracking.

This important new development is another Alcoa contribution to aviation progress. For complete technical information on this and other Alcoa aircraft alloys, write: Aluminum Company of America, 1800-B Alcoa Building, Pittsburgh 19, Pennsylvania.



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factory, complete with offices, stores, radio and instrument repair shops, fully provided with test equipment, heat and surface treatment equipment, at Woensdrecht. Aviolanda engineers are engaged in research as to the use of plastics in aircraft, as well as the development of a pilotless operated target drone AT-21.

Floorspace is 500,000 sq. ft. and personnel 1,500.

Royal Netherlands Air Force at present consists of 15 squadrons equipped with jet planes, one transport squadron with C-47s and two squadrons with helicopters and light aircraft.

There are two bases for the Training Command: Gilzerryen and Woensdrecht, with, respectively, Fokker S-11s and Harvards and Gloster Meteor Mk. 7s and Fokker S-14s.

The eight fighter squadrons of Air Defense Command fly with Gloster Meteor Mk. 8s, Hawker Hunters Mk. 4 and F-86K Sabre all-weather fighters.

The seven fighter squadrons of Tactical Command have been equipped with F-84Fs, RF-84Fs, T-33s and RT-33s. During 1956 there was a conversion in Tactical Command to F-84F and RF-84F.

In NATO the Royal Netherlands Air Force is integrated with USAF; on Soesterberg AFB a USAF squadron equipped with F-100C Super Sabres has been stationed and incorporated with the Dutch Air Defense Command.

The Royal Netherlands Naval Air Service now consists of seven squadrons, while two squadrons are at present out of commission until equipped with SeaHawks. The following aircraft are used: Firefly, Avenger, Beechcraft, Catalina, Mariner, Sikorsky helicopters and Neptunes.

Spain Continues Air Expansion

Madrid—American build-up and modernization of the Spanish air force, which made substantial headway in 1956, will continue through 1957.

The plan is to equip Spain with nine squadrons of jet fighters (225 aircraft). At the end of January, 1957, Spain had received 152 F-86Fs, five C-47s with 10 more on the way, 30 T-33s, 60 T-6s with 60 to come, and 15 Beech T-34s.

Rate of delivery is geared to the ability of the Spanish air force to have trained personnel to fly and maintain the planes. The first F-86s arrived in September, 1955, two years after the signing of the Spanish-American bases-for-aid accords.

A milestone was the creation in April, 1956, of an Air Defense Command under Lt. Gen. Julian Rubio Lopez of the Spanish air force. In effect, the Spanish ADC will be a joint operation with the U.S. Air Force and will be comparable in structure to the United States ADC. Its main features will be interceptor aircraft and a system of Aircraft Control Warning stations (ACW). The Spanish air force is now going into the active phase for securing the air defense of Spain, and has already had talks on defense coordination with Portugal and EUCOM.

Spain's Air Defense Command will be jointly operated and manned by United States and Spanish personnel and provides for the presence of USAF interceptors. Defense of the Strategic Air Force bases now nearing completion will thus depend on squadrons of USAF all-weather interceptors as well as on the jets of the Spanish air force.

The Spanish air force has several jet squadrons in operational status: the SAF First Wing at Valencia, elements of a second wing at Saragossa, one squadron on the island of Mallorca. American training of Spanish airmen continues at operational units in Europe and in the United States.

The 485-mi. pipeline to feed fuel to the American bomber bases in Spain was completed at the close of 1956 and is expected to be operational by mid-April, 1957, after a three-month testing period. Storage tanks at the Rota naval base are being filled; 55,000 barrels of fuel were off-loaded in January to start what will be a continuing process.

The bases at Torrejon, Saragossa and Moron will have minimum operational capability by mid-April 1957, with the POL and navigational aids in operation. The 7600th Air Base Group presently in Madrid will move to Torrejon headquarters about July 1. By fall of 1957, staffing of the bases will have started. They are expected to be fully operational by spring of 1958. A fourth base at San Pablo (Seville) will serve as a SAC depot center.

The 11,700 ft. runway at Rota is nearing completion.

Cut in Funds Slows Philippine Jet Plan

Manila—Philippine Air Force lost ground during 1956 in its jet aircraft expansion plans due to a $2,000,000 cut in its annual appropriation.

The PAF has six T-33 jet training aircraft that were turned over to it by the United States last August. It had been hoped that its jet pilot training program could be followed up by a gradual conversion of its fighter wing from World War II F-51s to late jet types. With cut in appropriated funds, this project has been curtailed.

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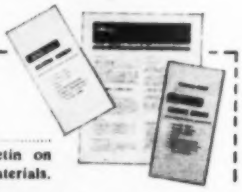
Write for bulletin on CHR's soft sealing material which gives basic facts on new R-11568, compares it with silicone sponge rubber and silicone foam rubber (COHRfoam).



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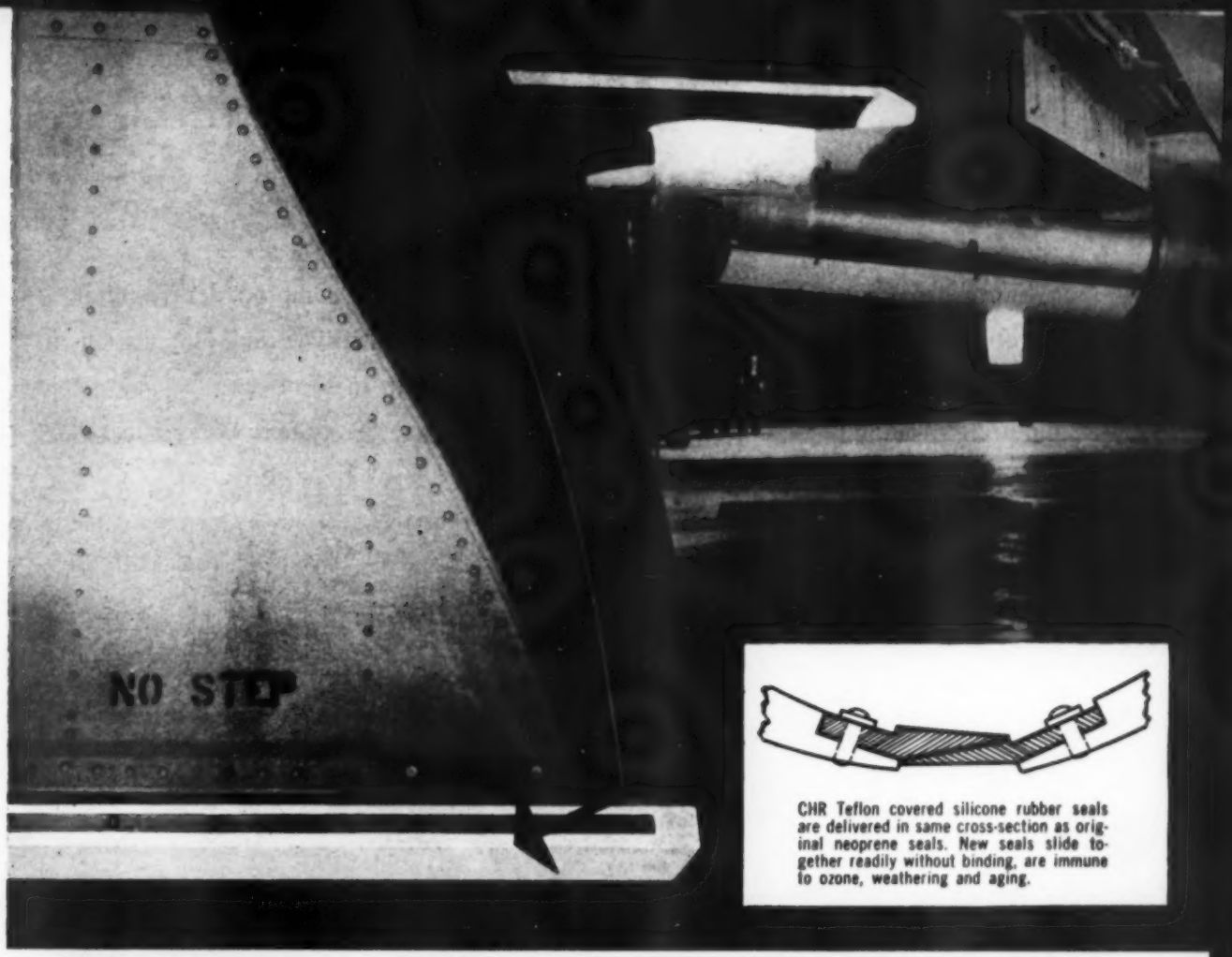

CHR Teflon covered silicone rubber seals are delivered in same cross-section as original neoprene seals. New seals slide together readily without binding, are immune to ozone, weathering and aging.

CHR adapts new seal development to B-47 bomb bay doors.

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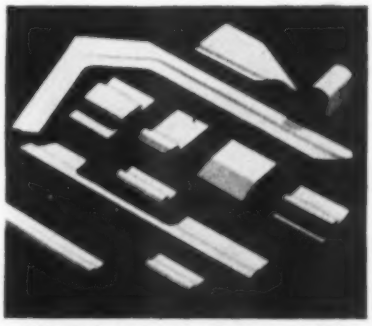
Extreme low temperature operating conditions played havoc with the neoprene rubber seals originally designed for B-47 bomb bay doors. Hardened by aging and cold, many of the seals split and ripped off when doors were opened and shut in flight.

CHR Teflon covered silicone rubber seals shown above solved the problem. Silicone rubber is immune to ozone, weathering and aging. The almost frictionless Teflon surface permits seals to mate readily without cracking or binding. The seals have -100°F to 500°F flexibility. They seal out and also shed water, ice and dirt. The white color provides reflective protection against radiation from nuclear weapons.

CHR Teflon covered seals are also being used on other planes where low friction, sliding action, abrasion resistance and resistance to fuels and synthetic lubricants is required.

Our experience in helping engineers with all types of airframe and engine seals utilizing all forms of silicone rubber reinforced with fabrics, Teflon and metals can be put to work for you. We solicit your inquiries for specific applications. Call or write. CHR field representatives are available for direct contact.



CHR Teflon covered seals are now being produced in many shapes and forms using all types of silicone rubber . . . solid, sponge and foam (COHRfoam).

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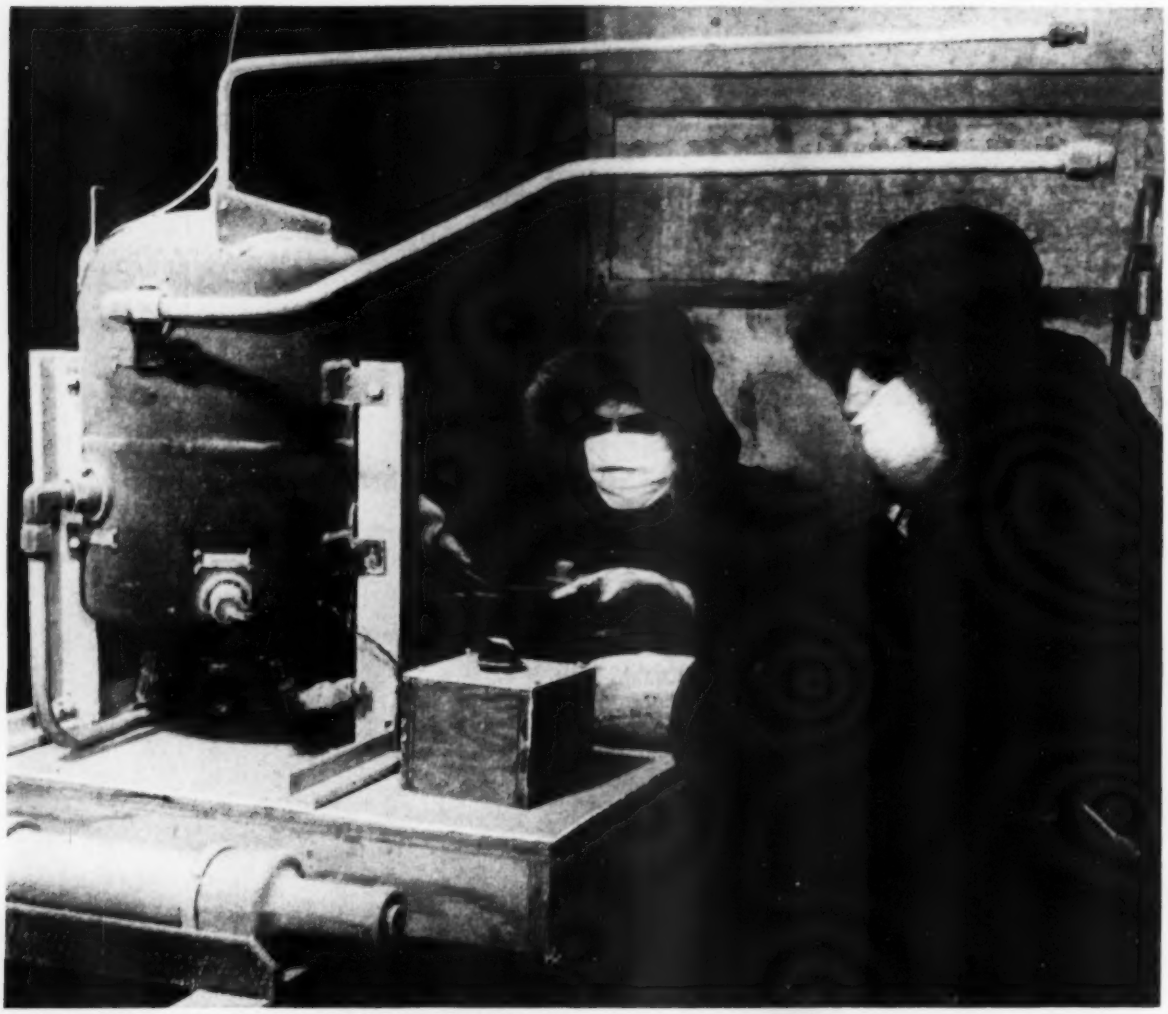

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Write for the full story: Mr. J. H. Papin, Personnel Manager, Dept. 56 2-W, North American's Columbus Division, Columbus 16, Ohio.

THE COLUMBUS DIVISION OF

NORTH AMERICAN AVIATION, INC.

FIAT G. 91

Small Italian Air Industry Is Growing

Rome—Output of the Italian aircraft industry last year was 25% higher than that for the previous year. However, it is a small industry, probably employing no more than 4,000 workers, and 1956 output did not exceed $35 million.

These figures are a misleading measure of the recovery effort made by the Italian aircraft industry.

In 1956 Italian industry flew two jet fighters, the first of purely Italian design. Both are light, low-cost aircraft with low operating costs:

• **Fiat G. 91,** ground attack subsonic aircraft was built on a design approved and financed by NATO. Fiat has started building 27 pre-series aircraft which have been ordered by NATO.

• **Saggittario II,** built by Aerfer of Naples in two models: an interceptor and one for ground attack. It has exceeded the speed of sound in a dive. It is an experimental aircraft which will be followed by the Ariete, a supersonic fighter. Seven pre-production aircraft have been ordered for which the U. S. has made an aid grant of $1.3 million.

Saggittario II weighs about 10,000 lb. Its ceiling is in excess of 46,000 ft. When fitted with a rocket engine in addition to regular turbojet it will surpass Mach 1 in horizontal flight.

Saggittario II has the engine mounted forward with tail cone beneath the center of fuselage. Center section of the fuselage carries fuel. Another jet engine or rocket can be fitted in the tail.

Most important commercial results in 1956 consist of sales in foreign markets of training and private planes built by Piaggio of Genoa, of Bell helicopters built under license by Soc. Costruzioni Aeronautiche Giovanni Agusta of Milan and of the air-to-air missiles of Stacchini Co.

Piaggio is building the P. 149, a five-seat business plane which can be used also for training and acrobatic displays. Germany has ordered 75 and has applied for a manufacturing license. Halso is building the 4-5 passenger P. 1361 amphibian known as the Royal Gull in the U. S.

Production of Bell 47 helicopters by Agusta offers an example of technical and commercial collaboration with American industry. First Agusta-Bell 47 helicopter was delivered in September 1954. In 1955, fifty were turned out and 133 in 1956. Production now has risen to 25 helicopters per month. Most are exported.

Agusta helicopters are exported to European countries and their possessions, on which the agreements with Bell allow free competition.

For the first time, Italy's missiles were sold on foreign markets. In competition with French, Swiss and German-Spanish industries, the Stacchini Airone air-to-air missile weighing 22 lb. won a contract from Japan.

New undertakings planned by the Italian aviation industry, for the more important of which the Government has appropriated about $35 million for grants in aid, include these types:

• **Macchi MB326,** a jet training plane fitted with the British Viper engine; 500 mi.; speed 450 mph.

• **Amphibious** twin-engine turboprop P. 155 built at Piaggio for air-sea rescue or for anti-submarine warfare.

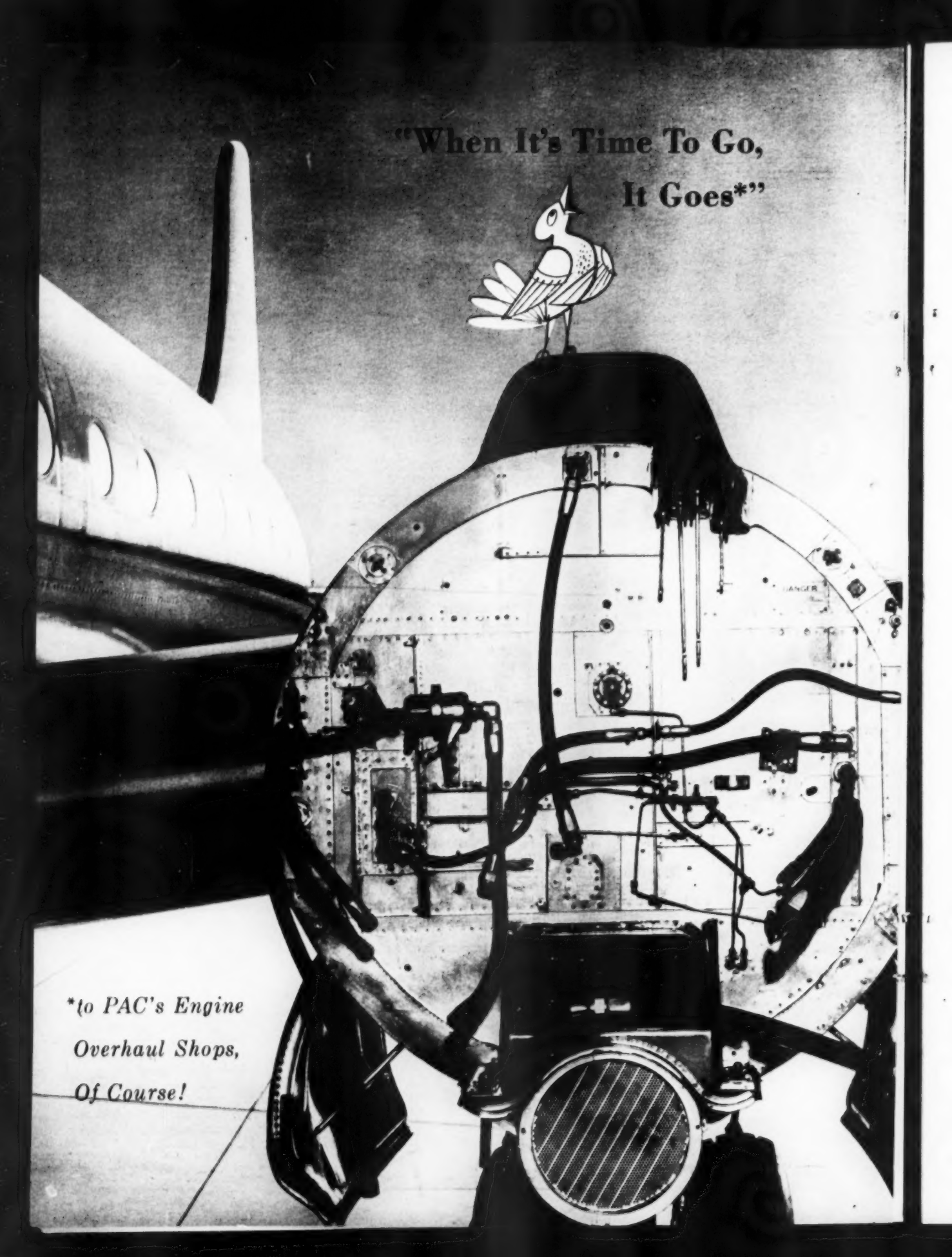
• **Turboprop military** transports now being studied by Piaggio and Savoia Marchetti.

• **X1 helicopter** designed for Agusta to carry eight passengers in addition.

Most Italian fighter squadrons have been provided with F-84Fs and F-86Ks. This has been made possible by American aid equal to $160 million for airplanes alone.

Because of low military appropriations, Italian fighter pilots have been able to fly about 70% of the standard established for NATO.

The Italian Air Force now consists of three air brigades of fighter-bombers incorporated in the Fifth ATAF and provided with F-84Gs and F-84Fs; a tactical reconnaissance air brigade also with the Fifth ATAF and provided with RF-84Fs; an all-weather fighter air brigade provided with F-86Ks; an interceptor fighter air brigade provided with Canadian-built Sabres; a squadron of fighter interceptors in Fiat Vampires; an air brigade of transports using C-119s; two anti-submarine groups in Harpoons. There are also some squadrons of Bell 47 helicopters. In all, IAF has over 700 planes, an increase of 25% over 1955.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● JAPAN

Japan Air Force Grows With Aid From USAF

By Dan Kurzman

Tokyo—Japan's three-year-old Air Self-Defense Force was converted in 1956 from a preparatory non-operational organization into a full-fledged defense arm. It embraced 519 planes at the end of the year, compared to 325 in 1955.

This increase, while mostly from USAF contributions, included 26 T-33A jet trainers and four F-86F Sabre jets assembled in Japan under a program to provide 180 home-made aircraft of each model by mid-1958.

Japanese air officials are not satisfied with this progress. They are hampered in their development program by the lack of funds and a delay in construction plans for new airfields resulting from politically inspired demonstrations against land appropriation for this purpose.

The budget problem will be slightly alleviated in 1957, as about 25%–5% more than last year—of an expanded defense budget will be devoted to the air force at the expense of the navy. The land obstacle is also expected to be overcome.

In any case, the air force plans to spend one billion yen ($2.7 million) for airfield construction and expansion in Fiscal 1957, starting in April, 300 million yen more than in 1956. Three new airfields will be added to the four all-Japanese and three joint U.S.-Japanese bases now in use—Nittabara, in Kyushu (runway: 7,000 ft.); Hyakuri-hara, near Tokyo (8,000 ft.), and Utsunomiya, near Nikko (6,000 ft.).

One old airfield—Shizuhama, near Nagova (6,000 ft.)—will be rehabilitated. Runways will be extended at Matsushima, near Sendai; Miho, in southern Honshu, and Komatsu, in central Honshu. Miho and Komatsu are U.S. bases, but they may be turned over to Japan this year.

Last year, only one new field was built—Yanome, near Sendai (5,000 ft. runway). Hamamatsu, near Nagova, had its runway extended to 8,000 ft.

Parallel with airfield expansion, the JASDF fleet is scheduled to grow from 519 to 779 aircraft by the end of 1957. Sabres are likely to increase in number from 138 to 275, T-33As from 98 to 180, T-34s from 120 to 127, T-6s from 130 to 155, and C-46s from 30 to 32. Personnel will probably increase from 13,000 (including about 800 pilots) to more than 20,000.

JASDF's first tactical fighter unit, the 2d Fighter Wing, was activated in September. It consists so far of 30 F-86s. The 1st Fighter Wing, a training unit of 73 Sabres, is located at

PAC ADDS JETS TO ENGINE OVERHAUL PROGRAMS

Over 18,000 aircraft engines, from the world's most powerful types to lighter power-packages for private aircraft have passed through the overhaul shops of Pacific Airmotive. Airline operators and private owners alike have learned to rely on PAC's factory overhaul methods, experience, and unmatched standards of dependability. PAC's production line techniques, skilled personnel, and complete inventories of parts and materials result in important savings in both time and cost.

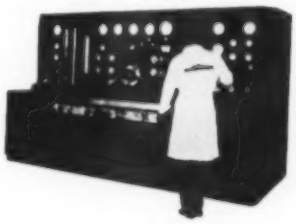
IT IS NOTEWORTHY that PAC is the first private organization to perform rework and modification (including test and calibration of accessories) of J-57 engines, leaving no doubt of PAC's leadership in the engine overhaul field!

LONG-TERM contracts providing for overhaul of Pratt & Whitney R-2800-CB engines of the Flying Tiger Line and Slick Airways fleets have been added to PAC's DC-4 engine overhaul contracts now in effect with these same carriers. This brings to eleven the number of airlines who contract with PAC for engine overhaul.

PAC TEST EQUIPMENT production has reached a new high in deliveries with facilities being rapidly expanded at both the Linden, N.J., and Burbank, Calif. manufacturing plants. Whenever specialized engine and accessory test equipment is needed for entirely new uses, PAC's engineering and production capacity provides the answer. In development at PAC's Linden plant are entirely new types of test and ground equipment for jet engines. Currently, PAC is working with major airlines to provide test and overhaul equipment for their jet powered fleets now on order. One of the reasons why PAC has become America's center for engine repair and overhaul is that much of the test and

overhaul equipment used is of PAC design and manufacture—engineered to perform with accuracy and complete reliability.

PACAERO Engineering Corp., formed to continue the production



An example of PAC's line of test equipment is the combination fuel, vacuum, hydraulic pump and accessories test stand shown above.

of the incomparable "Learstars" is another PAC contribution to the business and executive aircraft industry. In facilities covering over 240,000 square feet at Santa Monica, Calif., PacAero will continue modification and re-manufacture of all types of aircraft. PACAERO and PAC's overhaul facilities provide aircraft overhaul and modification services not available from any other source.

PRATT & WHITNEY Aircraft Engine Forums will again be conducted under PAC auspices this year. Forums are scheduled for Denver (May 14), Burbank (May 17), Oakland (May 20), and Seattle (May 22). Operators desiring to attend are invited to write PAC for reservations and arrangements for tie-down.

For aircraft operators who have specific requirements, brochures covering all phases of PAC services—engine overhaul, airframe overhaul and remanufacture, accessory overhaul, test equipment and ground handling equipment have been prepared. Write your nearest PAC plant; tell us your needs, and proper information will be supplied promptly

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Hamamatsu. Third Fighter Wing of 70 F-80s will be set up at Matsushima next September, and the 4th Fighter Wing of 50 Sabre jets at Hyakurihara base in February 1958. By 1960, the JASDF hopes to have 13 wings comprising 700 F-86s.

Diminishing dependence of JASDF on U.S. aid is reflected in production figures of the domestic aircraft industry. In 1956, Japan's nine aircraft companies turned out planes, instruments, and parts valued at 2,161 million yen ($6 million) and did repair and overhaul work amounting to 1,942 million yen ($5.9 million). In 1957, production is expected to total 9,700 million yen ($27 million), repair and overhauling, 2,500 million yen ($6.9 million).

Expenditure on research and experimentation by Japan's three leading aircraft companies—Shin Mitsubishi Heavy-Industries, Kawasaki Aircraft, and Fuji Heavy-Industries—will jump from $1.1 million in 1956 to $1.6 million in 1957. Investment in expansion by all companies—6,269 million yen ($17.4 million) last year—is, on the other hand, likely to drop this year to 4,234 million yen ($11.7 million) due to reduced need of new facilities.

• **Kawasaki's assembly** of T-33As is expected to increase from 27 in 1956 to 99. Domestic manufacture of parts is proceeding at a slower rate than anticipated due to the inexperience of the ten Japanese firms now turning them out with technical aid from U.S. companies. Kawasaki hopes to increase its output of Bell 47-G2 helicopters from 20 to 30 this year. It also figures on a boost in overhaul orders for jet engines from $1.6 million to $2 million, and for airframes from $500,000 to $700,000. Kawasaki spent about $4 million last year on expansion facilities.

• **Shin Mitsubishi** is scheduled to assemble 107 F-86s this year, as compared to four last year, when the assembly project got under way. It plans to start repairing and overhauling F-100 engines and bodies for the USAF this year.

It hopes to assemble and manufacture this plane in the future. Mitsubishi earned $1.6 million in 1956 from the overhauling and subassembly of about 100 F-86 airframes. It spent $9 million on expansion last year.

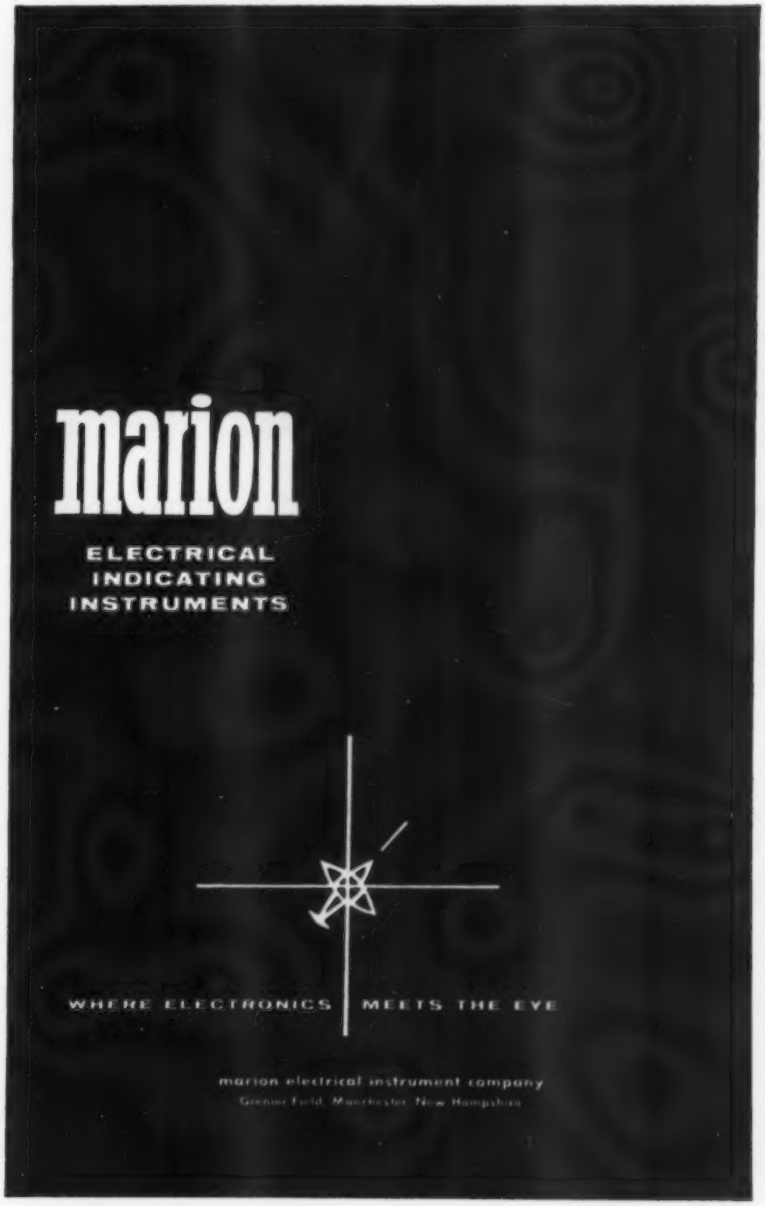
• **Fuji Heavy Industries** manufactured 26 T-34s in 1956, will probably turn out 22 this year. This firm is concentrating much of its energy to production of the T-1F1 light jet trainer. Preliminary production tests have been completed, and actual manufacture of this domestic design starts soon. Defense Agency has ordered four.

Fuji also contracted with the U.S. Air Force for the manufacture of 24 LM Liaison planes. Production will start in September, with the whole order due to be completed by April 1958. Fuji spent a total of about $1.3 million on plant expansion in 1956. Another $1.4 million will be expended in the next two years.

• **Shinmeiwa Industry Co.**, a smaller firm, is hoping to start assembly this year of the P2V-7, though government may not have the funds yet.

Ishikawajima Heavy Industries is expanding facilities for the manufacture of J47 jet engine parts, which will start in June. The firm may produce the entire engine for the F-86Fs in the not too-distant future. The Nihon Jet Engine Co., jointly established by five companies in 1953, will turn out for the Defense Agency this year three J3 jet engines, improved version of JO1.

The Defense Agency has set aside $1.5 million to push Japan's guided missile research plan in 1957. This sum includes $1 million for the purchase of an Oerlikon guided missile from Switzerland, and $150,000 for the purchase of 400 air-to-air rockets from Italy. The first firing tests of Japanese midget guided missiles took place last June. Plans are underway to test a large missile, complete with special features of the Oerlikon, this year. Air-to-air rockets, similar to the Italian type, will also be made in Japan this year to equip F-86s. The missiles and rockets will be produced with American aid.



The airframe industry at last glimpses prosperity on t
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For example, the Navy Bureau of Aeronautics recently formed an Avionics Division. Companies like Bell Aircraft, Emerson Electric, General Precision Laboratory, John Oster Manufacturing Co., Simpson Electric, and Sylvania now have Avionics Divisions or Laboratories. New companies like Avionic Products Engineering Corp.; Consolidated Avionics Corp. use the word in their corporate name. Many others use the word Avionics in their advertisements and literature.

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Industry Responds to Austerity Budget

Washington — Imminent contract withdrawals and readjustment of labor forces resulting at least in part from the proposed Fiscal 1958 austerity budget began to be felt by both the Air Force and aircraft industry last week. There were these manifestations:

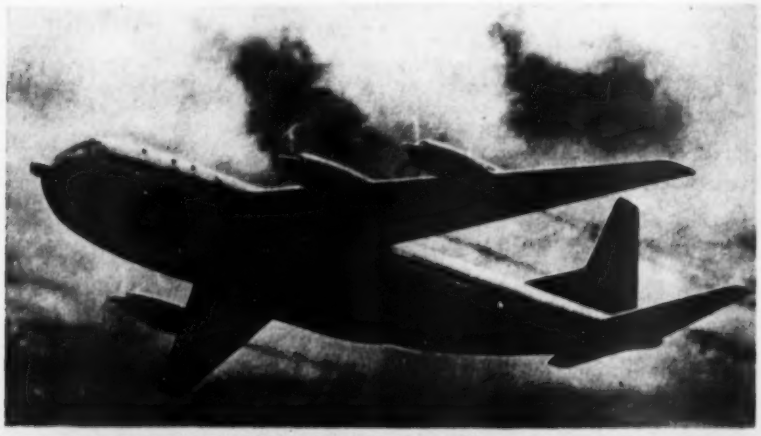
• **USAF indicated that** the Douglas C-132 transport project will not be continued despite both Air Force and Army reliance on its airlift capability in an age of nuclear warfare. Production prospects for the smaller Douglas C-133 are equally dim.

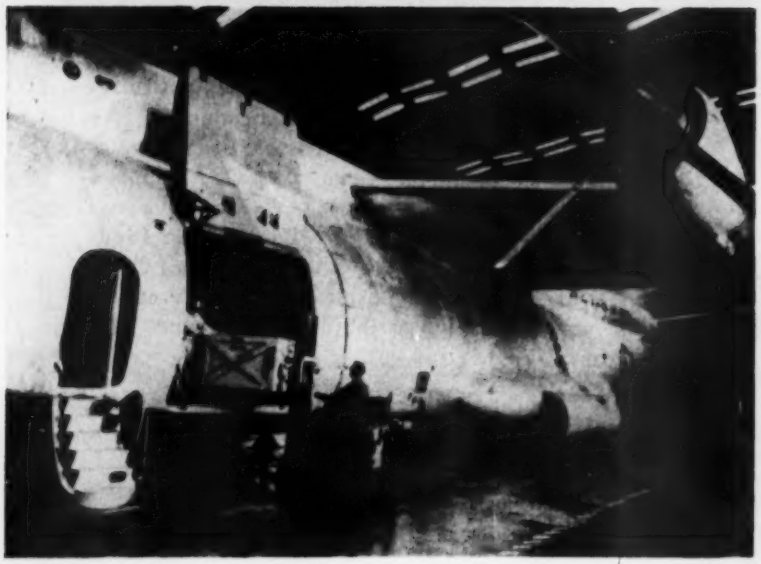
• **Republic Aviation Corp.,** Farmingdale, L. I., announced that 4,000 production workers will be discharged between March 1 and June 1. The company's F-84F goes out of production in August, and there is no indication that the new F-105 project will be continued.

• **Westinghouse Gas Turbine Division,** Kansas City, released more than 500 persons from its engineering offices. Most of these, a spokesman said, were clerical and other non-engineering personnel. The company is moving some engineers to its Pittsburgh plant.

• **North American Aviation, Inc.,** will reduce its payroll at Columbus, Ohio, Downey and Los Angeles, Calif. By April, 450 employes will be cut from the Columbus operation, where work on the FJ-3, T-28 and F-100D will be completed by the end of the year. On the West Coast, there have been readjustments in the Navaho missile programs.

• **Lockheed Aircraft's Marietta, Ga.,** plant is cutting its personnel by about 1,000 workers. The reduction began last October and will be completed by July 1. It is attributed for the most part to the phasing out of B-47 production.





MOCKUP of Douglas C-132 is probably all that USAF or the Army will ever see of this 100,000-lb. payload transport. Facing a budget with no funds for transport aircraft, the Air Force is expected to abandon the project. Plans called for speed in excess of 460 mph., maximum overload takeoff weight of more than 500,000 lb. The turboprop aircraft, a key item in future military logistic planning, was to be built at the Douglas Tulsa plant.

Mounting Political Pressure

Evidence of mounting political pressure to salvage at least some of the USAF program destined to suffer under the proposed budget came with the announcement that the Douglas C-132 may be terminated. The Pentagon announcement was made after a visit to USAF Secretary Donald A. Quarles by an Oklahoma delegation led by Democratic Sen. A. S. Mike Monroney. The C-132 was to have been built at the Douglas Tulsa plant.

Top-level USAF officers were embarrassed by an earlier lower-echelon release of facts on the C-132 and photos of the mockup at a time when the new budget includes almost no money for transport-type aircraft. The administration has been reluctant to discuss this possibility, particularly in view of testimony made during the airpower investigation by the Senate Air Force Subcommittee last summer.

At the hearings, Army officers said they expected new planes, the Douglas C-132 and C-133, to replace the C-124 for strategic lift requirements. They said USAF's present airlift capability is inadequate for Army purposes and indicated that it can be improved only through the addition of new and larger planes.

Future of Tulsa Plant

Secretary Quarles assured the Oklahoma group that USAF and Douglas will find some way to keep the company's Tulsa plant in operation. There was speculation that it might be used to build B-52 wing sections if Congress forces an increase in the rate of production of the big jet bomber. Douglas also presumably could move some of its commercial orders to the plant, but its military backlog now appears to depend primarily on Navy support.

USAF has about $91 million invested in the C-132, plus another $12 million laid out for facilities on the project. The original Air Force program called for two prototypes to be ordered from 1958 funds.

In other areas, there were no reports of personnel layoffs from McDonnell Aircraft or Lockheed's California plant despite the possibility that the

McDonnell's F-101B and Lockheed's F-104 will suffer some degree of slowdown, because of budget considerations.

The aircraft industry has not faced such difficulty in laying plans for the future since before the Korean war. Pentagon officials can be of no help, pending congressional action, and some degree of turmoil is certain to continue. Convair and Boeing Aircraft appeared fully confident of their ability to continue at full force. The stock market, for the most part, reflected Washington speculation on how available USAF money will be spent.

Industry spokesmen said the present layoffs will do almost nothing to relieve the shortage of engineers and skilled workers. Even Republic, laying off 4,000 workers, is still hiring engineers.

At a forum on the manpower problem held here as part of the Second National Jet Age Conference of the Air Force Assn., Lt. Gen. Clarence S. Irvine, USAF Deputy Chief of Staff for Materiel, warned the industry that USAF expects it to solve its own problem in this field. He added the customer will not tolerate hoarding of talent. The cure for this, the General indicated, will be to have the cost of overmanned engineering staffs disallowed on USAF contracts. He said the Renegotiation Board will support USAF in this attitude.

The demand for talent, Gen. Irvine said, is immediate and it will increase, but it is the highly trained specialist and technician that will be in shortest supply.

USAF's requirement for reliability, the increased complexity of weapon systems and the shift to missiles from manned aircraft are factors in Gen. Irvine's confidence that the industry's manpower requirements will not diminish. The shift, he indicated, is one of emphasis, dictated by the increasing importance of technology.

CF-105—1,600 mph.

Ottawa—Performance details of Avro Aircraft's CF-105 interceptor specify a speed of 1,600 mph. and a ceiling of 63,000 ft. which it will be able to reach in 3-4 min.

The delta wing interceptor, christened the Avro Arrow, will be powered by two Orenda Iroquois engines, rated at 20,000 lb. thrust and at 30,000 lb. with afterburner. It will weigh about 68,000 lb., twice that of the Avro CF-100, and it will fly three times as fast as its predecessor.

Air Marshal Roy Slemon, Chief of the Air Staff, who revealed the figures in a speech to the Air Cadet League of Canada, said the CF-105 would make its first flight this year.

"FLYING" ejection seat for Mach 2 has stub wings, wind deflector and vertical fins.

New Ejection System Cuts G-Load

Hurricane Mesa, Utah—Air Research and Development Command is completing full-scale model tests of a supersonic ejection system designed for Mach 2 speeds and both high and low-altitude bailouts.

Developed by Lockheed Aircraft Corp. and adaptable to most of USAF's jet fighters, interceptors and bombers, the seat is undergoing tests at the supersonic Military Air Research Track here. Lockheed says the seat will reduce the G load after bailout by about 50%.

Stanley Aviation Co., Denver, has a contract to build six test seats, and first production models are scheduled to be available by mid-1957. Among the system's features:

- **Vertical fins** which extend eight inches from the seat back and run the full four-foot length of both sides. Vanes give seat yaw stability, enabling occupant to be always facing forward.
- **Stub-like wings** 12 in. long and eight inches wide located on either side of the seat. The wings have an aerodynamic wing-loading factor slightly higher than the stub wing of the F-104A.
- **Steel wind** deflector mounted on a four-ft. boom in front of the pilot.

Prior to flight, the crewmember connects himself to the seat-attached parachute by means of a specially designed harness. This is what happens when he pulls the ejector ring:

- **Knee guards snap** into position to prevent leg spreading and counteract effects of outward airloads.
- **Arm support webbing** jumps upward to prevent any outward movement of the arms.
- **Metal stirrups** pull the feet close to the body until time for the crewmember's separation from the seat.
- **Lateral head supports** clamp against the sides of the helmet to relieve neck loads.
- **When the seat clears** the plane, a skip flow generator telescopes forward and the seat's side vanes swing open.

Automatic parachute deployment normally takes place when the indicated airspeed is less than 300 kt. and the altitude under 15,000 ft. A combination barometer-airspeed indicator attached to the parachute automatically controls its opening. For low-speed, low-altitude (as low as 400 ft.) escapes, the parachute opens immediately.

White House to Use Bell H47-J Helicopter

Washington—White House will take delivery on a Bell H47-J helicopter sometime near the end of March. Initial use will be to ferry President Eisenhower between the executive mansion and Washington National Airport.

The Air Force will provide both the helicopter and crew. According to Lt. Col. William G. Draper, USAF aide to the President, it may be six months before Eisenhower takes his first ride.

The four-place H47-J can carry a pilot and three passengers.

Airlines Will Sacrifice Power To Obtain Lower Jet Noise Level

Washington—Airlines are ready to sacrifice loss of jet engine power through use of power-cutting noise suppressors rather than risk a breakdown of airport-community relations.

Terming the noise nuisance of jet engines a major problem in the airlines' future, Milton Arnold, Air Transport Assn. vice president, told the Air Force Assn.'s Jet Age Conference here that the airlines will not begin jet transport service until turbine engine noise is reduced to piston-engine level.

Arnold said a satisfactory noise suppressor that reduces the Boeing 707's noise to a level lower than that reached by the DC-7 is "now in existence."

Gen. Thomas D. White, Air Force vice chief of staff, told the conference that the military cannot afford to cut noise and thus lower jet engine performance for "this would defeat the very ends we are trying to achieve."

Gen. White was optimistic over the eventual development of an effective, non-power-cutting jet engine noise suppressor and said the Air Force is conducting a research and development program toward that end.

USAF-Community Relations

Meanwhile, he said, other measures are being taken to strengthen community-Air Force relations. He cited the use of sound baffles at airports and the scheduling of engine run-ups at times when noise is less bothersome as two examples.

Boundary layer control, reverse thrust and vertical takeoff aircraft are other developments that will diminish the in-flight noise nuisance, Gen. White said.

He added:

"As missiles more and more replace airplanes, our noise problems should reduce in proportion."

He warned, however, that the sound of jet noise will be heard by more citizens as a result of a USAF program to disperse combat forces.

Community Education

Gen. Joseph McNarney, president of Convair Division of General Dynamics Corp. called for an educational program to combat the noise problem. He said "90% of any opposition that may develop in any community can be overcome with good community education."

Gen. McNarney outlined the educational program being conducted by Convair in cooperation with the Air Defense Command as a means of gaining more favorable public acceptance of Convair's F-102A. He said the program assumed that "for the present, little could be done technologically to alleviate the noise situation" and added: "We could not eliminate the noise but we might create understanding and tolerance for it."

He said the program includes orientation tours of the Air Defense Command headquarters at Colorado Springs and Convair's plant at San Diego. The tour involves a cross-section of key citizens whose influence on community attitudes and viewpoints is known.

Both Gen. McNarney and Gen. White cited successes obtained in favorable community relations at Truax Field in Madison, Wisc., where a fighter interceptor squadron equipped with F-102s is based.

According to Gen. McNarney, "the base has had no complaints since the F-102s arrived, although the flight pattern is directly over the Wisconsin Capitol."

However, the Madison issue drew fire from the floor when M. A. Skuldt, a civilian official of Truax Field, protested the position of the runway in relation to a heavily populated section of the city.

Skuldt said Truax Field officials had been "surprised" to learn that appropriated funds had been spent on improving the original runway rather than on a new runway that would keep landings and takeoffs away from the densely settled area.

B-52 Accident Causes Detailed

Washington—Reasons behind three of the five major Boeing B-52 accidents thus far were outlined last week by Dudley Sharp, Assistant Secretary of the Air Force for Materiel. Causes of the other two have not yet been determined.

In reply to inquiries by Rep. B. F. Sisk (D.-Calif.) and members of the House Armed Services Committee, Sharp defended the B-52's safety record and said it compares "favorably" in this respect with its B-36 and B-47 predecessors.

"The B-36 and B-47," he said, "have both established enviable records as effective strategic weapons and as safe operational aircraft. The accident rate of the B-36 and B-47 is below the USAF average. At the same number of operational flying hours following initial introduction, the B-52 has an accident record which is comparable favorably with that record established by the B-36 and B-47."

At the 15,500 flying hour level of operational flying, Sharp gave this comparative report on accidents—B-52, four fatal accidents and four aircraft destroyed; B-36, three fatal accidents and two aircraft destroyed; B-47, four fatal accidents and ten aircraft destroyed.

On the four B-52 crashes that have been investigated, Sharp reported:

• **The first,** which occured in flight near Castle AFB, Calif., on Feb. 16, 1956, was determined to have been the result of a failure of the driving mechanism of an alternating current generator. "This mechanism," Sharp explained, "is part of a relatively new concept in aircraft engineering" and "still may have areas where further improvement can be expected." As a result of an investigation of the accident, Sharp said 17 recommendations for improvement are being "expeditiously" acted upon.

• **Second B-52 accident,** on July 24, also at Castle AFB, occurred during combat readiness training landings and resulted from a failure of a portion of the pneumatic drive which operates the plane's hydraulic system.

• **The third at Castle** AFB on Sept. 17 occurred during flight. Investigation has not yet revealed the exact cause of the accident.

• **Primary cause of the fourth** accident on Nov. 30, at Castle AFB, Sharp reported, "is assessed to be that the aircraft was inadvertently flown into the ground at a critical point during flight with an abnormal nose down trim condition which the pilots did not or could not correct because of an unknown malfunction or distraction."

Details are not yet known, Sharp said, of the most recent B-52 crash, near Loring AFB, Me., on Jan. 10.

Doolittle Reports On ICBM Problems

Washington—Major problems involving structures, configuration, propulsion, guidance and aerodynamic heating must be solved before the intercontinental ballistic missile can become a practical weapon system, according to Lt. Gen. James H. Doolittle, new chairman of the National Advisory Committee for Aeronautics.

Doolittle, in a speech at an Aviation Writers Assn. meeting last week, cited the vital necessity of having the guidance system properly in phase with the duration of the ICBM's rocket motor. It is essential, he said, that the weapon be properly pointed and traveling at a precise speed when the fuel runs out.

B-58's Versatile Pod Concept

Convair B-58 Hustler is undergoing flight tests carrying the external weapons pod around which the supersonic bomber was designed. Pod shown is probably combination pack with fuel cells in nose and tail and "special weapon" in center section. Similar packs have been tested on other USAF airplanes. "Wool tufts" hidden in shadow under wing and on various parts of the pod indicate aerodynamic interference between pod and airframe is being studied. Negative angle at which pod is mounted should reduce Mach wave interference and assist separation of pod when it is dropped. Pack shown has no propulsion system but versatility of pod concept permits use of rocket powered air-to-ground missile or bomber defense missiles.

If 1% of the propellent is not used, the missile may miss the target by hundreds of miles.

For research into these areas, the NACA is asking for $41.5 million in new equipment in its Fiscal 1958 budget now before Congress. About half this amount is needed for facilities to carry on hypersonic research, and it will take as much as three and one-half years to build them.

French Cut U. S. Jetliner Purchases

Paris—French Finance Ministry has authorized purchase by Air France and two private French lines of only 14 American jetliners instead of the 23 originally requested. The move was predicted in AVIATION WEEK (Feb. 4, p. 57).

Under Ministry's ruling, Air France can place a new order for seven jets similar to transcontinental version of Boeing and Douglas jetliners or Convair 880.

Air France had asked permission to place an order for 14. Just which type Air France will order won't be decided for several weeks. Company's original order for 10 long range Boeing jets is unaffected by the new ruling. But its option on an additional eight Boeings, which must be picked up this year, is subject to further discussion between Air France and Finance Ministry.

Ministry's ruling also limits jet orders already placed by Transports Aeriens Intercontinentaux (TAI), and Union Aeromaritime De Transport (UAT).

TAI had ordered four Douglas DC-8s and UAT five of the same. Under the ruling, TAI gets two and UAT gets two. Both companies intend to fight the Ministry's decision.

Government's cutback in the jet orders is part of a general scheme to reduce government expenditures, particularly in the dollar area.

A few weeks ago the influential French High Council for Commercial Aviation recommended that, of the request for purchase of 23 jetliners, Air France should get eight, TAI should get two, and UAT should get three, for a total of 13. Finance Ministry then cut this recommendation still further, down to 11.

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Gerfaut Mark II Beats World Climbing Mark

Paris—French state-owned Nord Company claims its Gerfaut Mark II lightweight interceptor has beaten the world record for climbing speeds.

Gerfaut II, first flown Jan. 23, is powered by Snecma Atar G with afterburner developing about 10,000 lb. thrust. Record flight was made Feb. 16 at French air force test base at Istres.

Gerfaut II climbed to 6000 meters in 1 min. 22 sec.; 9,000 meters in 1 min. 41 sec.; 12,000 meters in 2 min. 18 sec.

Official record is held by British twin-jet Canberra for same altitudes, respectively, 1 min. 52 sec. 2 min. 25 sec.; 3 min.; 7 sec.

Nord says its times may be altered slightly when final radar records are known. It then plans to apply for official confirmation from Federation Aeronautique Internationale.

Company also announced its Gerfaut II on another flight climbed to 15,000 meters in 3 min. 35 sec.

It is understood that during record climb speed of craft was 625 mph. Because of climb angle Pilot Andre Turcat was unable to see out of the cockpit and made the run on instruments.

Britain Reduces Its Armed Forces

London—The Macmillan government plans to slash Britain's armed forces by 65,500 men during the 1957-58 fiscal year. It would leave 804,500 men and women in uniform.

Army would lose 42,000 officers and men, 40,000 of them from the 340,000 troops now serving in Europe, including Britain. It would cut army strength to 443,000.

Royal Navy would be reduced by 6,500 to 121,500.

Royal Air Force would drop by 17,000 to 240,000.

The budgets presented to parliament by Defense Minister Duncan Sandys cover the "first four or five months of the 1957-58" fiscal year, and come to a round figure of $1,610,000,000.

Chancellor of the Exchequer Peter Thorneycroft in presenting his "little budget" to the House of Commons said details of Britain's Defense Realignment would have to await publication of the Defense White Paper.

This is expected around the end of next month, prior to the full budget presentation. The military money proposals outlined are intended to give the services working cash for the first few months of the financial year.

Thorneycroft's "Little Budget" statement to the Commons was concerned

chiefly with civil expenditures for Fiscal Year 1957-58. He estimated them at $7,431,200,000, which is $308 million more than the original estimates for that period.

Biggest chunks of the budgetary pie are divided this way (change from the original 1956-57 budget in parentheses):

- **National Health Service:** $1,470,000,000 (up $137 million).
- **Education:** $1,150,000 (up $176 million).
- **Atomic energy:** $275 million (up $86.8 million).
- **Welfare foods:** $61.3 million (down $39.2 million).

In presenting his case to the government, Thorneycroft was interrupted by noisy, angry comments from the Laborite members. But he insisted that increasing civil and defense expenditures were imposing a burden on the economy which the government could not ignore. He said it represented a threat to the high level of public and private investment on which productivity depended.

Russian Science Lead Predicted in 10 Years

Washington—Russia will have the best scientists in the world and capture the technological leadership from the U. S. within 10 years, according to Dr. Edward Teller, professor of physics at the University of California and a builder of the first hydrogen bomb.

Dr. Teller told the Second National Jet Age Conference of the Air Force Assn. that his pessimistic prediction is supported by these observations:

- **Russian** technicians and scientists occupy a high position in their society in both material things and prestige.
- **Scientific** freedom of thought—not permitted in Russia for many years under Stalin—is now encouraged and has opened the door to new advances. End of restrictions has brought fast development in the past two years and the pace will increase.
- **U. S. scientists** are looked upon as "high-brow" and lack the prestige given to people in other fields. This atmosphere is not conducive to scientific accomplishment.
- **Scientific** education in the U. S. is lagging, largely because of a lack of inspired teachers and pupils.

Air Defense Groups Given Nuclear Missiles

Washington — U. S.-based interceptors of the Air Defense Command are being armed with rockets carrying nuclear warheads, Defense Secretary Charles E. Wilson announced last week.

Name of the missile was not dis-

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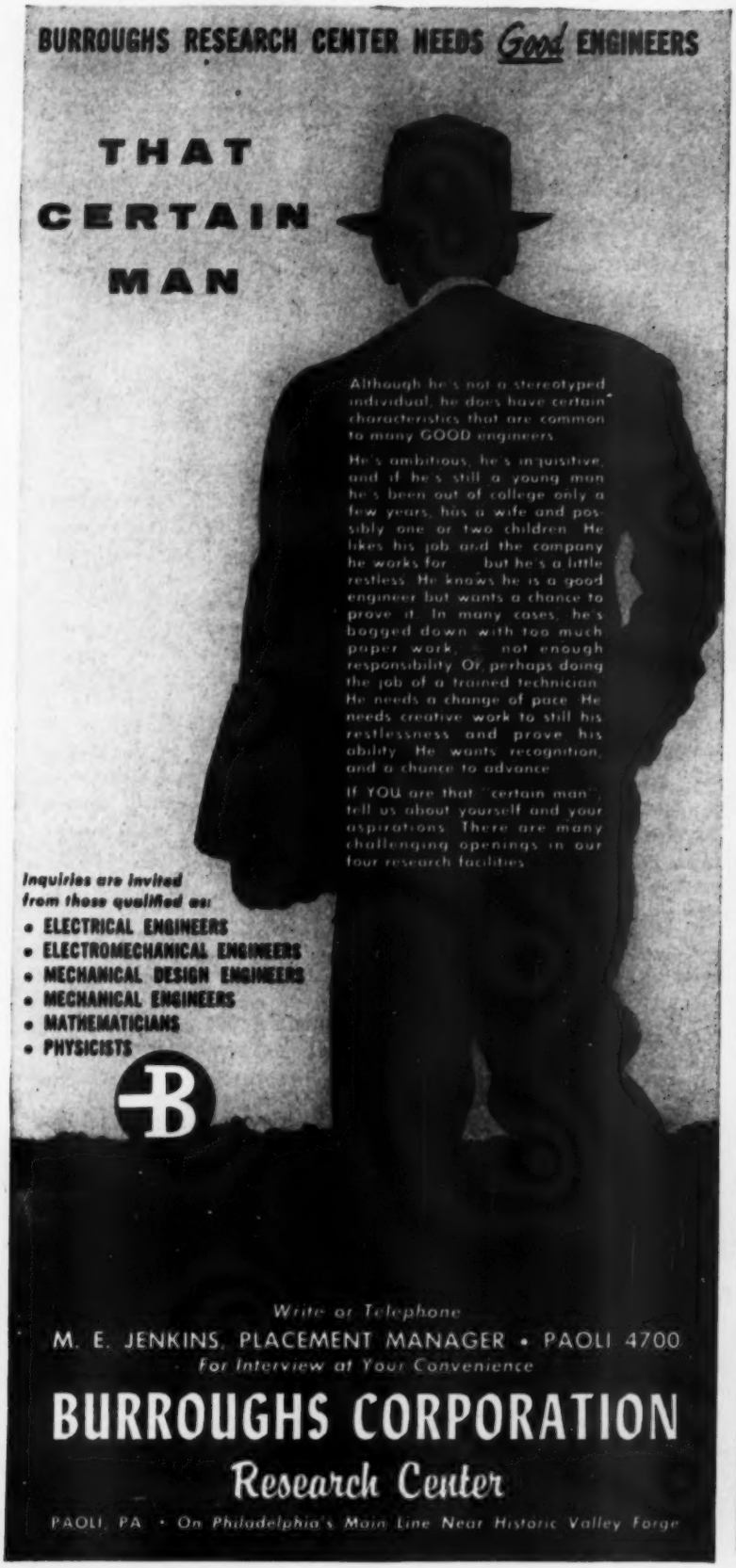
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closed in the statement designed to placate possible public concern over rumors that nuclear weapons were being stored at Air Defense Command bases and carried on fighters. The Air Force indicated that the missile has no name.

Presumably it is the Douglas Ding Dong, which has been rechristened since delivery to operational units started early last month.

Wilson said the missile will greatly increase the firepower of USAF interceptors. He said the Atomic Energy Commission has tested the missile and proved there is almost no possibility of accidental discharge involving impact or fire.

The secretary said nuclear warheads will later be installed on the surface-to-air missiles Nike-Hercules and Talos.

'Changed Conditions' Block Vertol Merger

Hawthorne, Calif.—Proposed merger of Vertol Aircraft Corp. with Northrop Aircraft Inc. (AW Oct. 15, p. 31) has been abandoned.

Action by Northrop to halt negotiations after nearly five months of discussion was attributed by officials of the two companies to these circumstances:

• **Failure of Piasecki Aircraft Corp.** to sign documents placing its stock in a voting trust prior to a joint meeting of the Vertol and Northrop boards on Jan. 16.

This forced postponement of action on the merger.

Frank Piasecki insisted to AVIATION WEEK that he had signed the document. He did not say, however, that he had signed it prior to the Jan. 16 joint meeting of the two boards.

• **"Changed conditions"** which appeared after the postponement.

The "changed conditions" were not itemized in statements issued by Don R. Berlin, president of Vertol and Whitley C. Collins, president of Northrop.

However, it became known in mid-January that the Army has altered its procurement program to eliminate 36 cargo helicopter companies and further follow-on contracts for the Vertol H-21C (AW Jan. 14, p. 30).

A few weeks later, Navy's Bureau of Aeronautics awarded a development contract for a new utility helicopter to Kaman Aircraft, eliminating a Vertol design that was a strong contender in the competition.

In a letter to Vertol shareholders, Berlin explained that Northrop insisted that stock owned by Piasecki Aircraft be placed in a trust because the company would compete with the new concern. Piasecki Aircraft is headed by Frank N. Piasecki, ousted board chair-

Fuel Tax Writeoffs

Washington—Office of Defense Mobilization is offering fast tax writeoffs in an effort to boost the production of liquid rocket fuels for missiles. In passing on individual applications for the benefits, ODM said it would consider "suitability of location and adequacy of transportation facilities in relation to missiles projects." ODM's goal is for delivery of four billion cubic feet of liquid oxygen and liquid nitrogen.

man of Vertol, and holds a number of military contracts, several of them in the rotary-wing field.

As of a year ago, Piasecki Aircraft owned 105,797 shares of Vertol common stock and listed this as the company's principal asset.

According to Berlin, a second prerequisite demanded by Northrop was an agreement by Laurence Rockefeller and his associates that they would place their Vertol stock in a voting trust if at any time in the future they acquired financial interest in a competing company.

Piasecki-Berlin Feud

The Rockefeller papers were executed prior to the Jan. 16 meeting. The Rockefellers are the largest Vertol stockholders and they would have owned a substantial share of the new company if the merger was consummated.

Failure of the merger proposal and attribution of part of the blame to Frank Piasecki climaxes a long period of bitterness and vituperative argument between the 37-year-old inventor and Vertol's Rockefeller-Berlin management. Piasecki quit the company, then known as Piasecki Helicopter Corp., in May, 1955, and established the new Piasecki Aircraft Corp.

Berlin Statement

About a year later, Vertol forced Piasecki to give up his seat on the board of directors because he was running a competitive business.

In his statement, Berlin told Vertol shareholders their annual report for 1956 will show an all-time high in sales of more than $90 million. Net earnings after taxes, he said, will soar to $3.4 million, more than twice the 1955 figure of $1.5 million. This is equivalent to $6.34 a share.

Last previous high was in 1953, when earnings per share of stock equalled $3.75.

Berlin said the backlog of orders at the start of 1957 was $117 million and that operations this year will continue at about the same level as 1956.

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Ross Replaced

Washington—Murray Snyder, former White House press assistant and an experienced newsman, has been appointed Assistant Secretary of Defense for Public Affairs. He replaces Robert Tripp Ross, who resigned under pressure from a congressional committee investigating his outside interests.

House Group Prepares New Industry Probe

Washington—House Armed Services Investigating Subcommittee is scheduled to begin today a new, and long, series of hearings on military aircraft procurement.

Initial testimony will come from the Army, Navy and Air Force on negotiated contracts. This will be followed by hearings on the procurement practices of airframe subcontractors.

Last year, the subcommittee, which is headed by Rep. Edward Hebert (D.-La.), completed lengthy hearings on procurement policies of the 12 major airframe manufacturers.

Questionnaires already have been mailed to aircraft engine manufacturers.

In addition to negotiated contracts, airframe subcontracting costs and aircraft engine costs, the subcommittee will also investigate policies on fixed price incentive contracts, standardization in the aircraft industry, lag between the appropriation of funds and contract letting for aircraft and airstrip paving costs.

Three More Airlines Ask for Fare Boosts

Washington—Three airlines announced last week that they would join United Air Lines and Capital Airlines in asking the Civil Aeronautics Board for a 6% increase in passenger fares.

Trans World Airlines will file a petition for a fare raise to become effective April 1. Both Delta Air Lines and Continental Air Lines have set April 15 as the date they want their increases to go into effect.

United and Capital made their bid for a fare boost earlier this month (AW Feb. 11, p. 43). In addition to the 6% increase, Capital asked for an across-the-board increase of one dollar on both first-class and coach tickets.

Late last week, both National Airlines and Northwest Orient Airlines indicated they may join the other carriers in petitioning for an increase.

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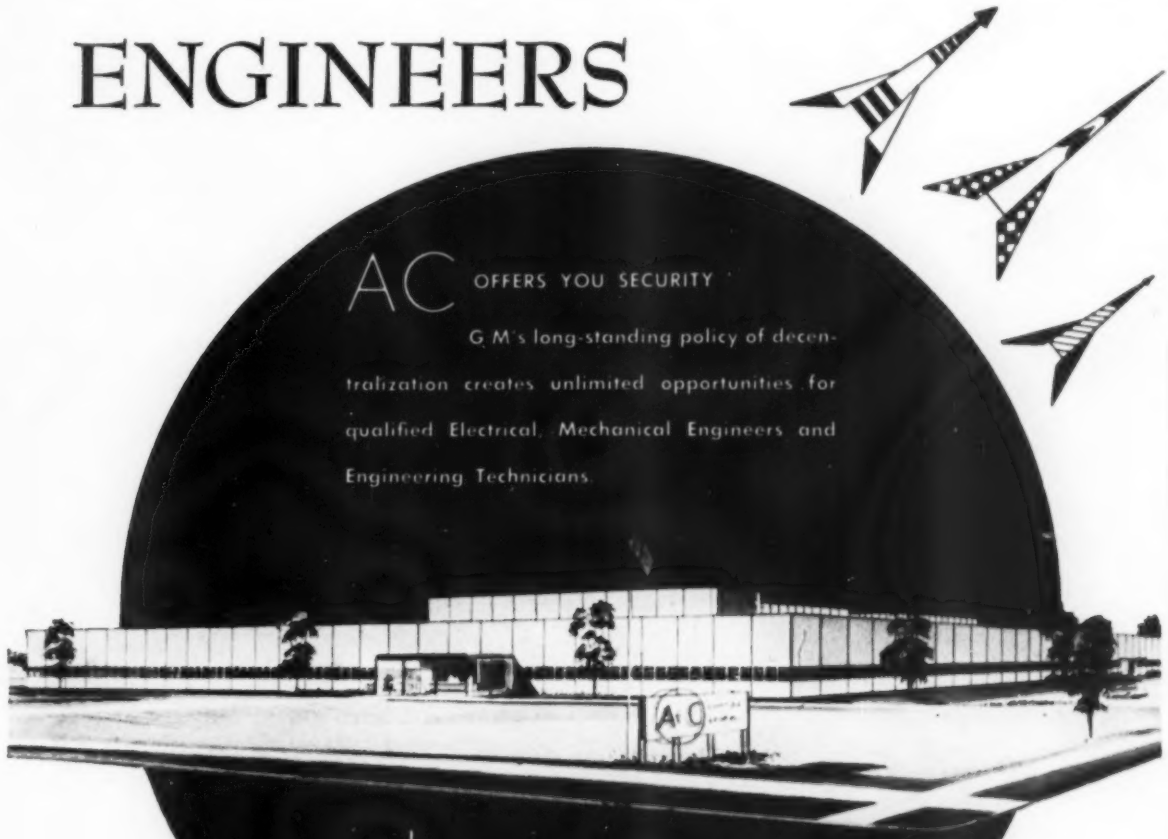
ENGINEERS



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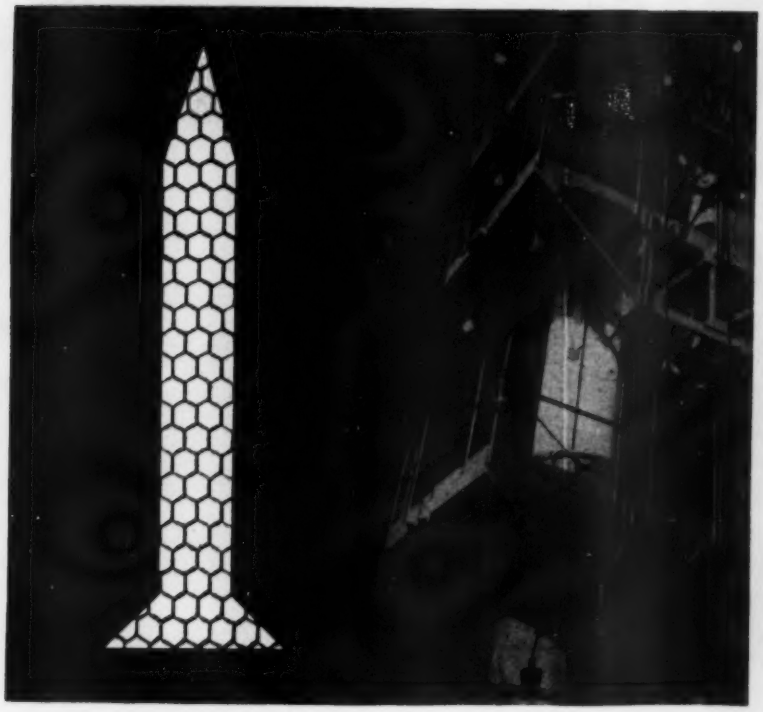

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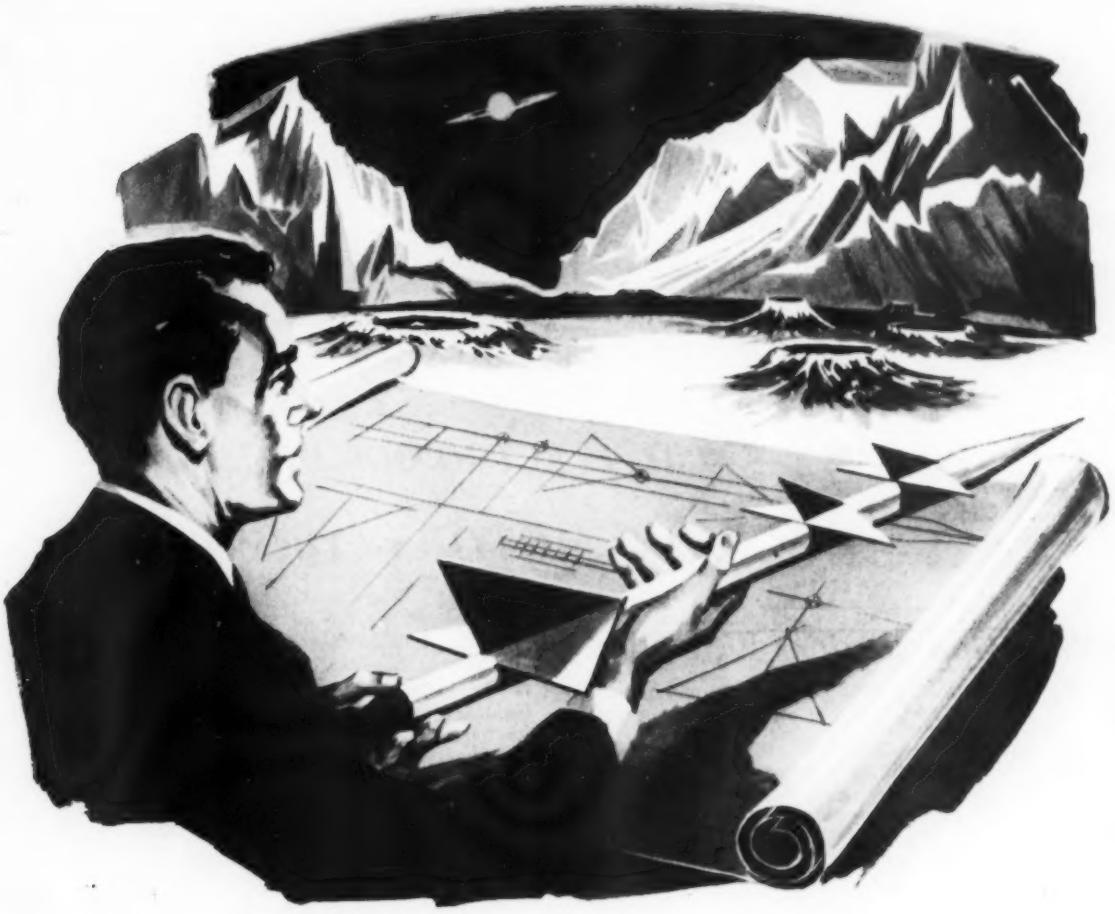

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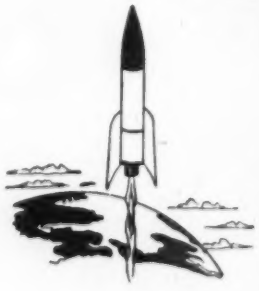

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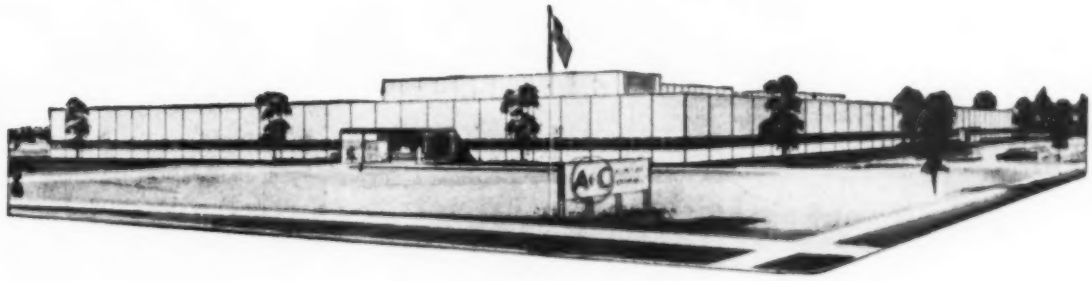

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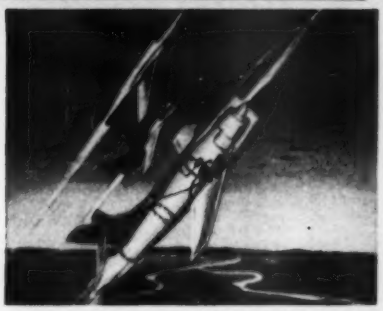

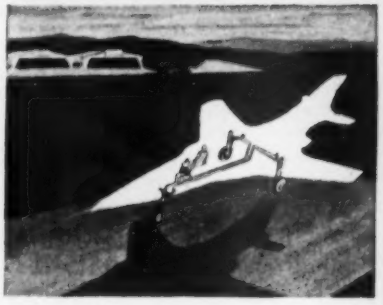

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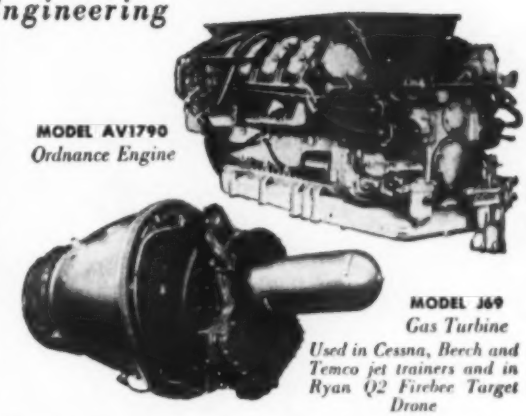

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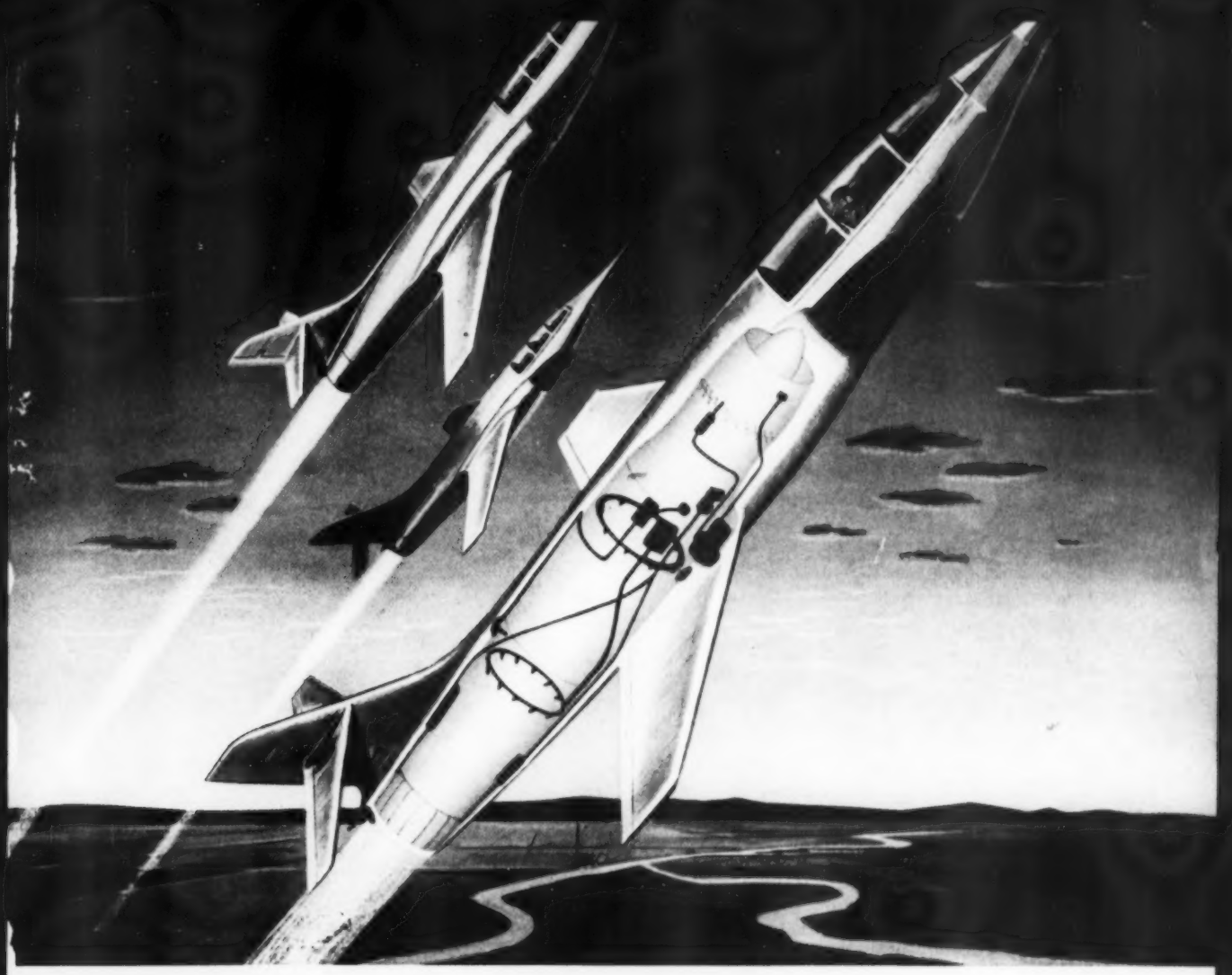

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